# Thermal resistance and estimated survival for the equipment in the CT 156 Harvard II aircraft seat survival kit

M.B. Ducharme
DRDC Toronto

P. Tikuisis
DRDC Toronto

P. Potter
The CORD Group

**Defence R&D Canada – Toronto**

Technical Report

DRDC Toronto TR 2003-109

July 2003

Author

M.B. Ducharme, PhD

Approved by

Pang Shek, PhD
Head, Operational Medicine Section

Approved for release by

K.M. Sutton
Chair, Document Review and Library Committee

© Her Majesty the Queen as represented by the Minister of National Defence, 2003.
© Sa majesté la reine, représentée par le ministre de la Défense nationale, 2003.

104-05595/


## Abstract

The main objective of the present study was to compare the thermal resistance properties of new proposed proposed and current equipment of the CT 156 Harvard II survival kit, and to estimate the survival times of aircrew during simulated winter survival scenarios using the proposed and approved survival kits. A thermal manikin was used to measure the thermal resistance of the survival kit equipment. Nineteen survival scenarios were tested representing dry and wet simulations on the ground and at sea. Survival times were estimated for all scenarios tested using the Cold Exposure Survival Model (CESM), the thermal resistance values obtained from the manikin, and CF aircrew anthropometric data. The results showed that only 4 of the 19 scenarios produced an estimated survival time of less than 12 hours, the minimum survival time selected as a criterion to pass the test. Those failing scenarios represented wet conditions on land using only the life raft to protect against heat loss, or the wet condition at sea. It was concluded from those results that as long as the sleeping bags are dry, any survival scenario on land using the proposed or approved equipment will produce an estimated survival time of over 12 hours. At sea, however, the estimated survival time is less than 12 hours for both the proposed and approved survival kit equipment when the clothing and equipment are wet. Functional limitations are reported for the proposed life raft.



## Résumé

La présente étude avait pour objectif principal de comparer les propriétés de résistance thermique des équipements, proposés et actuels, contenus dans la trousse de survie à bord du CT 156 Harvard II et d'estimer le temps de survie des membres d'un équipage d'aéronef utilisant les trousses de survie proposées et approuvées au cours de scénarios de simulations de survie en hiver. Un mannequin thermique a été utilisé pour déterminer la résistance thermique de l'équipement contenu dans la trousse de survie. Les essais ont été effectués au cours de dix-neuf scénarios de survie se déroulant sur terre et en mer, dans des conditions humides et des conditions sèches. Le modèle de survie à une exposition au froid (MSEF), les valeurs de résistance thermique obtenues du mannequin et les données anthropométriques de l'équipage des FC ont servi à l'estimation du temps de survie dans tous les scénarios d'essai. Selon les résultats, pour 4 des 19 scénarios, le temps de survie estimé était inférieur à 12 heures, soit le temps de survie établi comme critère de réussite. Les scénarios qui ont donné des résultats insatisfaisants correspondent aux conditions humides sur terre où les participants ne disposaient que du radeau de sauvetage pour se protéger contre la perte de chaleur, et aux conditions humides en mer. Les résultats ont permis de conclure que tant que les sacs de couchage sont secs, le temps de survie estimé de tout scénario sur terre, avec l'équipement proposé ou approuvé, sera de plus de 12 heures. Toutefois, en mer, qu'il s'agisse de l'équipement de la trousse de survie proposé ou approuvé, si l'équipement et les vêtements sont mouillés, le temps de survie estimé est inférieur à 12 heures. On a également signalé des limitations fonctionnelles du radeau de sauvetage proposé.

This page intentionally left blank.

## Executive summary

DND and its Military-Air Agent Bombardier Aerospace Defence Services (BA DS) are experiencing difficulties to fit the DND approved survival kit into the CT 156 Harvard II Survival Aids Container located under the aircrew seats. One option under study is to reduce the size of the equipment contained in the DND approved survival kit. The main objective of the present study was to compare the thermal resistance properties of the BA DS proposed equipment substitutes to the approved equipment of the current survival kit, and to estimate the survival time of aircrew during simulated winter survival scenarios within 1200 nautical miles of Moose Jaw while using the proposed and approved survival kits.

A thermal manikin was used to measure the thermal resistance of the proposed and approved survival kit equipment providing thermal protection, namely the sleeping bags, life rafts, mittens and balaclavas. Nineteen survival scenarios were tested representing dry and wet simulations on the ground and at sea. Survival times were estimated for all scenarios tested using the Cold Exposure Survival Model (CESM), the thermal resistance values obtained from the manikin, and CF aircrew anthropometric data. The results showed that only 4 of the 19 scenarios produced an estimated survival time of less than 12 hours, the minimum survival time selected as a criterion to pass the test. Those failing scenarios represented wet conditions on land using only the life raft to protect against heat loss, or the wet condition at sea. It was concluded from those results that as long as the sleeping bags are dry, any survival scenario on land using the proposed or approved equipment will produce an estimated survival time of over 12 hours. At sea, however, the estimated survival time is less than 12 hours for both the proposed and approved survival kit equipment when the clothing and equipment are wet. Functional limitations are reported for the proposed life raft.

Ducharme, M.B., Tikuisis, P., Potter, P. 2003. Thermal resistance and estimated survival for the equipment in the CT 156 Harvard II aircraft seat survival kit. DRDC Toronto TR 2003-109. Defence R&D Canada - Toronto.

## Sommaire

Le MDN et son contractant en aviation militaire, Bombardier Aéronautique, Services à la défense (BA SD) ont des difficultés à insérer la trousse de survie approuvée par le MDN dans les contenants de trousse de survie situés sous les sièges de l'équipage du CT 156 Harvard II. Une des possibilités en cours d'étude est de réduire les dimensions de l'équipement contenu dans la trousse de survie approuvée par le MDN. L'objectif principal de la présente étude était de comparer les propriétés de résistance thermique de l'équipement de remplacement proposé par BA SD à celles de l'équipement approuvé de la trousse de survie actuelle et d'estimer le temps de survie d'un équipage au cours de scénarios de simulation de survie en hiver effectués à moins de 1200 milles marins de Moose Jaw, avec la trousse de survie proposée et la trousse approuvée.

On a utilisé un mannequin pour mesurer la résistance thermique de l'équipement de protection thermique, notamment les sacs de couchage, les radeaux de sauvetage, les mitaines et les passe-montagnes, contenu dans la trousse de survie proposée et dans la trousse approuvée. Les essais ont été effectués au cours de dix-neuf scénarios de survie sur terre et en mer, dans des conditions humides et des conditions sèches. Le modèle de survie à une exposition au froid (MSEF), les valeurs de résistance thermique obtenues du mannequin et les données anthropométriques de l'équipage des FC ont servi à l'estimation du temps de survie dans tous les scénarios d'essai. Selon les résultats, pour 4 des 19 scénarios, le temps de survie estimé était inférieur à 12 heures, soit le temps de survie établi comme critère de réussite. Les scénarios qui ont donné des résultats insatisfaisants correspondent aux conditions humides sur terre où les participants ne disposaient que du radeau de sauvetage pour se protéger contre la perte de chaleur, et aux conditions humides en mer. Les résultats ont permis de conclure que tant que les sacs de couchage sont secs, le temps de survie estimé de tout scénario réalisé sur terre avec l'équipement proposé ou approuvé sera de plus de 12 heures. Toutefois, en mer, qu'il s'agisse de l'équipement proposé ou approuvé de la trousse de survie, si l'équipement et les vêtements sont mouillés, le temps de survie estimé est inférieur à 12 heures. On a également signalé des limitations fonctionnelles du radeau de sauvetage proposé.

Ducharme, M.B., Tikuisis, P., Potter, P. 2003. Thermal resistance and estimated survival for the equipment in the CT 156 Harvard II aircraft seat survival kit. DRDC Toronto TR 2003-109. Defence R&D Canada - Toronto.

# Table of contents


Abstract ..... i

Résumé ..... i

Executive summary ..... iii

Sommaire ..... iv

Table of contents ..... v

List of figures ..... vi

List of tables ..... vi

Introduction ..... 1

Methods ..... 2

- Estimation of the thermal resistance ..... 2
- Estimation of survival time ..... 5

Results ..... 7

- Thermal resistance ..... 7
- Predicted survival times ..... 8

Observations ..... 12

Discussion ..... 13

Recommendations ..... 16

References ..... 17

Annexes ..... 18

## List of figures

Figure 1. Plot of the predicted percent survival rate against time (h) for male pilots exposed to - 35°C, 20 km/h wind, and relative humidity of 70% with a torso thermal resistance of 1.5 Clo (see Table 5). ..... 10

## List of tables

Table 1. Equipment tested for their thermal resistance properties ..... 3

Table 2. Description of the manikin test conditions. The tests in air were conducted with the manikin laying on a 6 inch thick spruce bough bed. In test #17, the inflated life vest was added under the manikin's torso. The CORD Test # refer to the manikin tests performed by CORD (see Annex A). ..... 4

Table 3. Range and mean ± SD of the basic anthropometric characteristics of the data used for predicting ST. ..... 6

Table 4. Overall and torso thermal resistance obtained from the manikin tests. The CORD Test # refer to the manikin tests performed by CORD (see Annex A). ..... 7

Table 5. Predicted STs for various survival rates and torso thermal resistance values for an air temperature of -35°C, wind speed of 20 km/h, and relative humidity of 70%. ..... 9

Table 6. Predicted ST (in h) for different torso thermal resistance values (in parenthesis) for an air temperature of -35°C, wind speed of 20 km/h, and relative humidity of 70%. Thigh-level immersion in 0°C water was assumed for Tests #1892 and 1893 caused by the presence of water in the life rafts. Predictions for males (m) and females (f) are shown as mean ± SD, minimum, maximum, and for various survival rates. ..... 11

Table 7. Predicted ST (in h) for different torso thermal resistance values (in parenthesis) for an air temperature of 0°C, wind speed of 20 km/h, and relative humidity of 70%, and thigh-level immersion in 0°C water. Predictions for males (m) and females (f) are shown as mean ± SD, minimum, maximum, and for various survival rates. ..... 14

# Introduction

A seat survival kit contains survival equipment for use by aircrew in the event of ejection from the aircraft. The survival kit, contained inside the Survival Aids Container (SAC), is located in the limited space under the seats of aircrew. A list of essential survival equipment was developed and approved by DND for use in the CT 156 Harvard II aircraft. This list contains equipment for thermal protection such as a -30°C rated down sleeping bag, a one-man life raft, a balaclava, wool socks and wool/leather mitts, in addition to other survival equipment.

Recently, DND and its Military-Air Agent Bombardier Aerospace Defence Services (BA DS) have experienced difficulties to fit the DND approved survival kit into the CT 156 Harvard II SAC, despite attempts by BA DS to expend the dimensions of the SAC. As a result, BA DS must maintain a Search & Rescue (SAR) helicopter in Moose Jaw during cold weather operations to assist with survivability of aircrew in the event of ejection.

One option that is currently considered by DND and BA DS to solve this problem is to reduce the size of the equipment contained in the DND approved survival kit. BA DS has proposed more compact equipment substitutes for the currently approved survival kit and has requested DND to evaluate them to ensure compliance with the various DND regulations and standards.

Defence R&D Canada Toronto (DRDC Toronto) received a request from the Canadian Aerospace Training Project (CATP) to assist in the thermal evaluation of the proposed survival kit equipment. The aim of the study was to provide a qualitative and quantitative evaluation of the difference between the approved and the proposed survival kit equipment for the CT 156 Harvard II aircraft.

The specific objectives of the study were as follows:

1. To determine the thermal resistance of the sleeping bag, life raft, balaclava, and mitts as part of the DND approved survival kit for the CT 156 Harvard II SAC contents;

2. To determine the thermal resistance of the sleeping bags, life raft, balaclava, and mitts as part of the BA DS proposed survival kit for the CT 156 Harvard II SAC contents;

3. To compare the thermal resistance of the approved equipment against the proposed equipment of the survival kit;

4. To estimate the survival time of aircrew dressed in winter clothing and exposed to -35°C air with 20 km/h wind using the approved and proposed survival equipment in a dry and wet conditions;

5. To estimate the survival time of aircrew dressed in winter clothing and exposed to -35°C air with 20 km/h wind, and partial immersion in 0°C water using the approved and proposed survival equipment in a wet condition;

6. To provide comments on survivability issues related to the approved and proposed equipment of the survival kit.

# Methods

## Estimation of the thermal resistance

*General methodology.* The thermal resistance of the survival kit equipment providing thermal protection was evaluated using a 13-segment thermal immersion manikin (TIM from the CORD Group, Dartmouth, NS).

The equipment tested is described in Table 1. It consists of DND approved and BA DS proposed sleeping bags, life rafts (approved LRU-23P and proposed LRU-18/U), balaclavas and mitts.

The purpose of the manikin tests was to estimate the thermal resistance of the survival kit equipment in conditions simulating aircrew winter survival scenarios on the ground and in water. Three general scenarios were therefore used in the present study: survival of an

immobile winter dressed and dry aircrew on the ground; survival of an immobile, undressed and wet aircrew on the ground; survival of a winter dressed and wet aircrew in a life raft over water. During all the dry tests on the ground and all the water tests, the manikin was dressed with the current flight winter clothing consisting of a green cotton long top and bottom underwear, a flight suit, wool socks, winter weight flight boots, winter weight jacket, and winter weight pants. The Life Preserver / Survival Vest (LP/SV) was worn during the tests over water but not on the ground, except to provide insulation against the ground in one test. The flight helmet was not worn during the tests. During the wet tests on the ground, the manikin was undressed to simulate a scenario where the aircrew removed its clothing to keep the thermal properties of the down sleeping bag optimal. The immobile condition was used to simulate an injured aircrew with limited mobility.

***Table 1.*** *Equipment tested for their thermal resistance properties*

| STOCK/PART NUMBER | DESCRIPTION | PROPOSED OR APPROVED |
|---|---|---|
| FLO-7053-00 | Life raft, LRU-18/U<br>Dimension: 163 x 75 cm<br>Description: mummy shape, no water ballast bags, no floor bailer, 4 small buoyancy tubes staked on top of each other, bagged floor with 38 cm sag at head and 20 cm sag at feet. | Proposed |
| N/A | Life Raft, LRU-23P<br>Dimension: 140 x 95 cm<br>Description: 2 ballast water bags, a floor bailer, a single buoyancy tube, an inflated cushion. | Approved |
| XPD2 | Sleeping bag, Integral Designs, goose down filled, rated -30°C | Approved |
| BAG-1550-00 | Sleeping bag, Marmott Helium, goose down filled, -10°C rated | Proposed |
| BAG-1500-01 | Sleeping bag, Kelty, goose down filled, -4°C rated | Proposed |
| N 8415-21-874-4501 | White balaclava | Approved |
| N 8415-21-104-2111 | Mittens, wool extreme cold | Approved |
| N 8415-21-104-2125 | Mittens, leather shell | Approved |
| N/A | Balaclava, The North Face | Proposed |
| N/A | Mittens, The North Face Nuptse | Proposed |

*Manikin tests on the ground.* Seventeen manikin tests were performed on the ground as described by conditions tested 1 to 17 in Table 2. In all ground tests, the temperatures of the 13 segments of the manikin were kept uniform and constant at a value around 35°C to obtain a temperature difference between the manikin skin and the environment of at least 10°C. This temperature difference would optimize the calculation of the thermal resistance values. A wind intensity of 20 km/h was generated during all ground tests.

For each of the 17 tests, the manikin was dressed as described in Table 2 and was laid down over a 15 cm thick spruce bough bed. In the conditions where only the sleeping bag was used (conditions 1, 2, 3, 9, 10, 11), the manikin was positioned with its feet to the wind to minimize air drafts inside the sleeping bag. In the conditions where the life raft were used, the manikin was positioned inside the sleeping bag and then inside the closed life raft over the bough bed with the back of the manikin to the wind. In condition 17, an inflated LP/SV was positioned inside the bough bed under the manikin's torso to add additional insulation against the ground.

***Table 2.*** *Description of the manikin test conditions. The tests in air were conducted with the manikin laying on a 6 inch thick spruce bough bed. In test #17, the inflated life vest was added under the manikin's torso. The CORD Test # refer to the manikin tests performed by CORD (see Annex A).*

| CORD TEST # | CONDITION TESTED | DESCRIPTION |
|---|---|---|
| 1867 | 1 | Winter dressed, dry, proposed sleeping bag (-4°C), exposed to air |
| 1868 | 2 | Winter dressed, dry, current sleeping bag (-30°C), exposed to air |
| 1869 | 3 | Winter dressed, dry, proposed sleeping bag (-10°C), exposed to air |
| 1870 | 4 | Winter dressed, dry, current life raft, exposed to air |
| 1871 | 5 | Winter dressed, dry, proposed life raft, exposed to air |
| 1872 | 6 | Winter dressed, dry, current sleeping bag (-30°C) in current life raft, exposed to air |
| 1873 | 7 | Winter dressed, dry, proposed sleeping bag (-4°C) in proposed life raft, exposed to air |
| 1874 | 8 | Winter dressed, dry, proposed sleeping bag (-10°C) in proposed life raft, exposed to air |
| 1875 | 9 | Undressed, wet condition, current sleeping bag (-30°C) in air |
| 1876 | 10 | Undressed, wet condition, proposed sleeping bag (-10°C) in air |
| 1877 | 11 | Undressed, wet condition, proposed sleeping bag (-4°C) in air |
| 1878 | 12 | Undressed, wet condition, current life raft in air |
| 1887 | 13 | Undressed, wet condition, proposed life raft in air |
| 1888 | 14 | Undressed, wet condition, current sleeping bag (-30°C) in current life raft in air |
| 1889 | 15 | Undressed, wet condition, proposed sleeping bag (-10°C) in proposed life raft in air |
| 1890 | 16 | Undressed, wet condition, proposed sleeping bag (-4°C) in proposed life raft in air |
| 1891 | 17 | Undressed, wet condition, current sleeping bag (-30°C) in air over inflated life vest |
| 1892 | 18 | Winter dressed, wet condition, current life raft in water |
| 1893 | 19 | Winter dressed, wet condition, proposed life raft in water |

*Manikin tests over water.* Two of the nineteen tests were performed over water inside a life raft (see conditions tested 18 and 19 in table 2). For those tests, the manikin was dressed with winter clothing and completely immersed in water for 2 minutes to fully wet the clothing. After a waiting period of 1 minute in air during which the excess of water was lost from the clothing, the manikin was moved inside one of the life rafts in a sitting position with its buttocks against the provided inflated pillow. The system was then positioned over water

with the back of the manikin facing a 20 km/h wind. Before the start of the test, 8 liters of water was added to the life raft to simulate normal entry of water during rough sea condition.

The amount of water inside the life rafts was estimated from tests conducted in a pool using a human subject. During the tests, the subject, dressed with an immersion suit, was asked to board each of the tested life raft while trying to minimize water entry. Following the entry, the volume of water inside the life rafts was measured using a graduated bucket to within 0.1 L. The tests showed that 37.2 L of water entered the approved LRU-23P life raft while 101.2 L of water entered the proposed LRU-18/U life raft during the boarding procedure.

Following the entry tests, similar amount of water was introduced into the life raft and the subject was asked to remove as much water as practically possible using the integrated bailer of the approved LRU-23P life raft or a flight helmet for the proposed LRU-18/U life raft. Those tests showed that 3.8 L of water remained in the approved LRU-23P life raft and 3.7 L of water in the proposed LRU-18/U life raft. Since these tests were performed in the ideal conditions of a pool, a more realistic scenario involving constant water entry caused by rough sea conditions, water spray, intense wind, cold fingers, hypothermia (causing apathy) and possible motion sickness will likely leave a larger volume of water inside the life raft. It was estimated that 8 L of water (double the minimum observed) would be a reasonable volume inside a life raft during a survival scenario over rough water.

## Estimation of survival time

*General methodology*. The estimation of the survival time (ST) was performed using the Cold Exposure Survival Model (CESM) developed at DRDC Toronto (1, 2). The model assumes that the exposed individual is in an immobile position and has a normal thermoregulatory response to cold exposure. Predicted STs exceeding 36 h are not given because of the increased uncertainty of survival due to factors other than cold.

The thermal resistance values obtained from the manikin tests provided one of the basic parameters required by CESM to estimate the survival time. A second parameter was the anthropometric data from the CF aircrew population targeted by this study. Finally, a third parameter was the environmental conditions during the survival scenarios.

For the purpose of this study, the survival scenarios were limited to winter conditions during flight operations within 1200 nautical miles of Moose Jaw, including large open bodies of water. The minimum air temperature expected is -35°C with a baseline wind speed of 20 km/h. The minimum water temperature expected is 0°C.

Based on information provided by CATP, the maximum expected rescue time for this area is estimated at 12 hours. For this reason, the criterion for accepting the proposed survival equipment was defined as being an estimated survival time of at least 12 hours.

*Data*. Male pilot data (n = 387) used for the prediction of survival times were extracted from the 1985 survey of aircrew (3). Female data (n = 74) were based on a surrogate sample (provided by P. Meunier of DRDC-Toronto) using the current CF aircrew anthropometric selection criteria applied to the 1997 survey of the land forces (4). Table 3 shows the basic anthropometric characteristics of the data. The predicted STs for these data are also distributed and will be presented according to their range and mean.

*Table 3. Range and mean ± SD of the basic anthropometric characteristics of the data used for predicting ST.*

| VARIABLE | MALES (N = 387) | | FEMALES (N = 74) | |
|---|---|---|---|---|
| | *range* | *mean ± SD* | *range* | *mean ± SD* |
| AGE (YRS) | 20 – 52 | 31.1 ± 7.3 | 19 – 47 | 31.2 ± 6.5 |
| WEIGHT (KG) | 55.5 – 118.2 | 78.9 ± 10.7 | 54.2 – 118.4 | 74.8 ± 11.7 |
| HEIGHT (M) | 1.62 – 1.96 | 1.77 ± 0.07 | 1.62 – 1.79 | 1.70 ± 0.04 |

*Statistical analysis.* T-tests were performed to define the significance of the difference between the thermal resistance of the current and proposed mitts and balaclavas. Significance was accepted at $T < 0.05$. The data are presented as mean ± SD.

# Results

## Thermal resistance

Table 4 presents the thermal resistance values obtained for all of the manikin tests. The overall thermal resistance represents the weighted average obtained from the 13 manikin segments. The torso thermal resistance is the weighted average for the four segments representing the torso region of the manikin (chest, back, abdomen, and buttocks). The torso thermal resistance was used for the determination of the estimated survival time. In general, the thermal resistance obtained for the torso is higher than the overall thermal resistance.

***Table 4.*** *Overall and torso thermal resistance obtained from the manikin tests. The CORD Test # refer to the manikin tests performed by CORD (see Annex A).*

| CORD TEST # | CONDITION TESTED (SEE TABLE 1) | OVERALL THERMAL RESISTANCE (CLO) | TORSO THERMAL RESISTANCE (CLO) |
|---|---|---|---|
| 1867 | 1 | 3.39 | 4.79 |
| 1868 | 2 | 4.37 | 4.77 |
| 1869 | 3 | 3.96 | 4.77 |
| 1870 | 4 | 2.72 | 3.60 |
| 1871 | 5 | 2.67 | 3.99 |
| 1872 | 6 | 5.05 | 7.93 |
| 1873 | 7 | 3.39 | 6.00 |
| 1874 | 8 | 4.14 | 7.69 |
| 1875 | 9 | 3.44 | 3.83 |
| 1876 | 10 | 3.37 | 3.89 |
| 1877 | 11 | 1.72 | 2.41 |
| 1878 | 12 | 0.69 | 0.84 |
| 1887 | 13 | 0.87 | 1.04 |
| 1888 | 14 | 3.71 | 6.54 |
| 1889 | 15 | 3.42 | 5.66 |
| 1890 | 16 | 2.66 | 5.04 |
| 1891 | 17 | 3.21 | 4.29 |
| 1892 | 18 | 0.22 | 0.95 |
| 1893 | 19 | 0.15 | 0.73 |

*Dry versus wet tests.* The dry tests performed in air on a dressed manikin with a sleeping bag and /or with a life raft showed thermal resistance values above 3 Clo. The wet tests performed in air or over water with a life raft only showed thermal resistance values below 1 Clo.

*Approved versus proposed equipment.* In general, the overall thermal resistance of the current sleeping bag and life raft showed higher thermal resistance values as compared to the proposed sleeping bags and life raft. In addition, the thermal resistance of the -10°C rated proposed sleeping bag was in general higher as compared to the -4°C rated proposed sleeping bag. Significance could not be defined because of a low sample size.

*Mitts and balaclavas.* The thermal resistance of the current mitts averaged 2.8 ± 0.6 Clo and was not different from the thermal resistance of the proposed mitts averaging 2.9 ± 0.5 Clo.

The thermal resistance obtained for the current balaclava was 1.7 ± 0.2 Clo and was not different from the thermal resistance obtained for the proposed balaclava of 1.5 ± 0.4 Clo.

*Inflated LP/SV under the torso.* Test condition 9 and 17 (see Table 2) were identical except for an inflated LP/SV positioned under the torso of the manikin inside the bough bed in test condition 17. The inflated LP/SV improved the insulation against the ground and increased the torso thermal resistance by 12% (from 3.83 to 4.29 Clo).

The details of all the thermal manikin tests are presented in Annex A.

## Predicted survival times

The following predicted STs are based on the torso thermal resistance, as this variable was deemed most important during the development of CESM with regard to the onset of lethal hypothermia. The predictions shown in Table 5 pertain to several different generic thermal resistance values based on a severe winter condition.

*Table 5. Predicted STs for various survival rates and torso thermal resistance values for an air temperature of -35°C, wind speed of 20 km/h, and relative humidity of 70%.*

| CLO | GENDER | SURVIVAL RATE (%) | | | | |
|---|---|---|---|---|---|---|
| | | 95 | 75 | 50 | 25 | 5 |
| | | ST (H) | | | | |
| 0.1 | male | 1.0 | 1.1 | 1.3 | 1.4 | 1.5 |
| | female | 1.2 | 1.4 | 1.5 | 1.7 | 1.9 |
| 0.25 | male | 1.3 | 1.5 | 1.6 | 1.7 | 1.9 |
| | female | 1.2 | 1.5 | 1.6 | 1.7 | 2.0 |
| 0.5 | male | 1.9 | 2.1 | 2.2 | 2.4 | 2.6 |
| | female | 1.9 | 2.1 | 2.2 | 2.4 | 2.8 |
| 1.0 | male | 3.4 | 3.8 | 4.1 | 4.5 | 5.2 |
| | female | 3.0 | 3.5 | 3.9 | 4.4 | 5.4 |
| 1.5 | male | 5.8 | 6.7 | 7.5 | 8.3 | 9.9 |
| | female | 4.8 | 5.8 | 6.8 | 8.0 | 10.4 |
| 2.0 | male | 12.3 | 13.3 | 13.9 | 14.6 | 15.6 |
| | female | 10.0 | 11.3 | 12.2 | 13.0 | 14.3 |
| 2.5 | male | 21.6 | 23.4 | 24.6 | 25.8 | 27.5 |
| | female | 17.3 | 19.4 | 20.8 | 22.2 | 24.3 |

For a torso thermal resistance of 3.0 Clo, ST exceeds 30 and 36 h, respectively, for 100 and 98% of males, and 94 and 24% of females in the database (Table 3). Also note that ST ~ 12 h for a torso thermal resistance value of ~ 2.0 Clo. An example of the distribution of ST is given in Figure 1.

From Table 5, a survival rate of 95% for a torso thermal resistance of 1 Clo means that 95 male aircrews out of a population of 100 will survive an estimated 3.4 hours in the condition described.

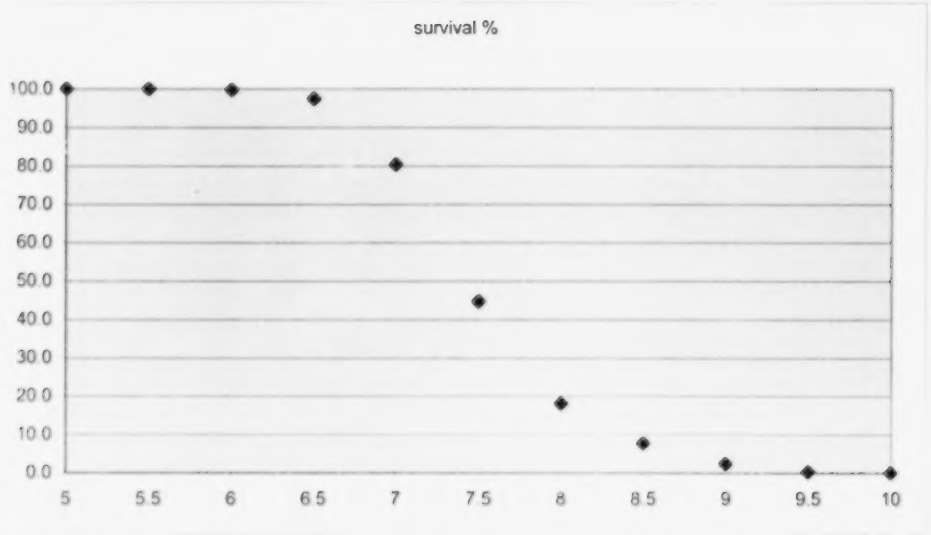


***Figure 1.*** *Plot of the predicted percent survival rate against time (h) for male pilots exposed to -35 °C, 20 km/h wind, and relative humidity of 70% with a torso thermal resistance of 1.5 Clo (see Table 5).*

The predictions shown in Table 6 pertain to specific torso thermal resistance values listed in Table 4. Results for only five test values are presented as all others yielded ST > 36 h.

***Table 6.*** *Predicted ST (in h) for different torso thermal resistance values (in parenthesis) for an air temperature of -35 ℃, wind speed of 20 km/h, and relative humidity of 70%. Thigh-level immersion in 0 ℃ water was assumed for Tests #1892 and 1893 caused by the presence of water in the life rafts. Predictions for males (m) and females (f) are shown as mean ± SD, minimum, maximum, and for various survival rates.*

| | TEST #1877 (2.406 CLO) | | TEST #1878 (0.836 CLO) | | TEST #1887 (1.040 CLO) | | TEST #1892 (0.949 CLO) | | TEST #1893 (0.733 CLO) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | *m* | *f* | *m* | *f* | *m* | *f* | *m* | *f* | *m* | *f* |
| **MEAN ± SD** | 22.2 ± 1.6 | 18.9 ± 2.0 | 3.4 ± 0.3 | 3.3 ± 0.4 | 4.3 ± 0.4 | 4.1 ± 0.6 | 4.0 ± 0.4 | 3.9 ± 0.6 | 3.1 ± 0.3 | 3.1 ± 0.5 |
| **MIN** | 17.6 | 15.4 | 2.6 | 2.6 | 3.4 | 3.2 | 3.1 | 3.0 | 2.3 | 2.3 |
| **MAX** | 27.1 | 25.6 | 4.4 | 5.0 | 5.6 | 6.3 | 5.4 | 6.2 | 4.1 | 4.8 |
| **95%** | 19.5 | 15.6 | 2.8 | 2.6 | 3.6 | 3.2 | 3.3 | 3.0 | 2.5 | 2.3 |
| **75%** | 21.1 | 17.6 | 3.1 | 3.0 | 4.0 | 3.8 | 3.7 | 3.5 | 2.8 | 2.8 |
| **50%** | 22.2 | 18.9 | 3.4 | 3.3 | 4.3 | 4.1 | 4.0 | 3.9 | 3.1 | 3.1 |
| **25%** | 23.3 | 20.2 | 3.6 | 3.6 | 4.6 | 4.5 | 4.3 | 4.3 | 3.3 | 3.4 |
| **5%** | 24.9 | 22.1 | 3.9 | 4.0 | 5.0 | 5.0 | 4.7 | 4.8 | 3.6 | 3.8 |

## Observations

*Mitts*. Based on their application for the 12-hour survival period, there is no evidence to support the inadequacy of the proposed mitts. During one of the manikin test, one wrist tighting strap from the approved mittens broke.

*Life rafts*. During the pool tests with the life rafts, the subject observed that it was easier to board the approved life raft and less water entered this life raft as compared to the proposed life raft. During the boarding process, it was observed that the narrow end of the proposed life raft was easily submerged under water. The proposed life raft was also more difficult to bail as water was collecting at the bottom of the bagged floor under the subject's buttocks. The bailing process was made more difficult by the narrow high sides that closed around the subject. It was also noted that the lower-body and upper-body-to-mid-chest level of the subjects were below the buoyancy tubes of the proposed life raft because of the bagged floor. This caused the bagged floor to press against the body because of the hydrostatic pressure of the water, likely increasing the body heat loss to the water and making the basic survival actions more difficult. During the boarding and bailing tests, the subject felt less stable in the proposed life raft as compared to the approved life raft.

## Discussion

*General findings*. The results from the present study indicate that the thermal protection provided by the proposed approved equipment of the survival kit will likely result in a survival time on land of over 12 hours, as long as a dry sleeping bag can be used by the aircrew. Over water when all the equipment is wet, it is unlikely that either the proposed or approved survival kit will provide a survival time sufficient to survive 12 hours. Those estimated survival times were calculated for the worst case scenarios expected during winter time within 1200 nautical miles of Moose Jaw and for immobile aircrew. Further test in the laboratory and / or the field using human subjects would be required to validate those estimated survival times.

The results from the present study also show that the thermal protection provided by the proposed and approved mittens and balaclavas are adequate for a 12-hour survival scenario, and no difference in thermal protection could be found between the proposed and the approved equipment.

*Land survival*. The most critical equipment for thermal protection during a land survival scenario is the sleeping bag. It was assumed in this study that the sleeping bag could be kept dry during land survival. It is critical for the aircrew to take all appropriate actions to maintain the sleeping bag dry during the survival period by removing all wet clothing and by using the life raft as a shelter before opening the sealed package containing the sleeping bag. A down sleeping bag will lose the majority of its insulation properties when wet. For this reason, it is advisable to propose a synthetic sleeping bag as a better option for the survival kit. Although a synthetic bag with the same thermal rating will likely be more bulky when packed, it would better retain its thermal properties when wet as compared to a down sleeping bag. Furthermore, since the estimated survival times for ground survival using the proposed and approved down sleeping bags exceed by far the 12-hour requirement, there is room to decrease the insulation of the sleeping bag if a synthetic sleeping bag becomes a viable option. This could be an important asset, particularly for sea survival when it is unlikely that a dry sleeping bag could be used and where survival is limited to few hours. Additional testing would be required to compare the thermal insulation and survival time for a wet down sleeping bag as compared to a wet synthetic sleeping bag for land and sea survival. This additional testing could provide a better balance between survival times on land and at sea.

It was also assumed in the present study that the aircrew could build a spruce bough bed to insulate oneself from the ground. This is particularly important since a large portion of the body heat loss is with the ground as the body applies pressure over the insulation of the sleeping bag, decreasing significantly its thickness and thermal protection. If a bough bed could not be build, it is advisable for the aircrew to use the inflated life raft cushion in addition to the inflated LP/SV to insulate oneself from the ground. Even with a spruce bough bed, it is advisable to use the inflated LP/SV under the torso since this action will improve the thermal protection over the torso region of the sleeping system by 12% (see tests 9 and 17 in Table 4).

*Sea survival*. The most critical actions to take during sea survival are to move out of the cold water as quickly as possible and to keep the water away from the body during the survival period. Hopefully, this could be achieved with a well designed life raft. The present study

showed that when all the equipment is wet, the proposed and approved life rafts will likely not provide sufficient protection to extend the survival period to 12 hours during the worst case scenario (heavy sea; air temperature of -35°C; water temperature of 0°C). In a milder scenario, where both the water and air temperatures are close to 0°C, the estimated survival time would be increased to about 15 hours for a 95% survival rate with the current life raft, and to 10 hours with the proposed life raft (see Table 7).

In the present study, the thermal resistance of the life rafts was tested when flooded with 8 liters of water in order to simulate a scenario of heavy sea and limited bailing capability. This volume of water was estimated as being reasonable since this represents only twice the minimum volume of water left inside the life rafts following an ideal bailing exercise. Field testing at sea would be required to obtain a more accurate estimate of the volume of water inside the life rafts during survival conditions. It is worth noting that the manikin tests were performed in calm water of a pool and it is likely, based on previous studies with immersion suits (5), that the thermal resistance of the life raft system would be lowered by wave action due to an increase in heat loss by water convection. Field testing at sea or in a wave pool will be required to estimate the effect of wave action on the thermal resistance of the life rafts.

***Table 7.*** *Predicted ST (in h) for different torso thermal resistance values (in parenthesis) for an air temperature of 0°C, wind speed of 20 km/h, and relative humidity of 70%, and thigh-level immersion in 0°C water. Predictions for males (m) and females (f) are shown as mean ± SD, minimum, maximum, and for various survival rates.*

| | TEST #1892 (0.949 CLO) | | TEST #1893 (0.733 CLO) | |
|---|---|---|---|---|
| | *m* | *f* | *m* | *f* |
| **MEAN ± SD** | 22.1 ± 3.0 | 19.8 ± 3.7 | 15.0 ± 2.3 | 13.9 ± 3.2 |
| **MIN** | 15.7 | 13.6 | 10.3 | 9.1 |
| **MAX** | 33.0 | 33.7 | 22.9 | 27.7 |
| **95%** | 17.1 | 13.6 | 11.3 | 8.6 |
| **75%** | 20.1 | 17.2 | 13.5 | 11.7 |
| **50%** | 22.1 | 19.8 | 15.0 | 13.9 |
| **25%** | 24.2 | 22.3 | 16.5 | 16.1 |
| **5%** | 27.1 | 25.9 | 18.7 | 19.2 |

Some design limitations were observed, particularly for the proposed life raft and are reported in the Results section of this report. Those limitations are responsible for an overall thermal resistance 30% lower as compared to the approved life raft. The difference is attributed

particularly to the un-insulated sagged floor design of the proposed life raft that keeps the water inside the life raft and the walls in close contact with the body, increasing the heat loss to the water. Furthermore, the sagged floor design of the proposed life raft would likely impact on the capacity of the aircrew to bail out water and to perform some of the basic self-rescue techniques.

A previous study comparing insulated with un-insulated life raft floors showed that body heat loss was on average 33% higher and skin temperature 12°C lower following a 1-hour use of an un-insulated floor life raft as compared to an insulated floor life raft (6). Using a life raft with an inflatable floor would likely significantly improve the survival time over water, although it will also increase the bulkiness of the survival kit. Further testing would be required to investigate the impact of other life raft designs on survival time.

Based on the present study, survival at sea with the proposed and approved survival kit will unlikely meet the criteria of 12-hours survival during the worst case scenario. One potential solution could be to propose a better designed life raft without a sagged floor or with an inflatable floor to decrease body heat loss to the water. Another potential solution could be for the aircrew to use an immersion suit when they are flying over large open cold water during winter time. An immersion suit could serve as winter clothing and will better protect aircrew during water immersion by limiting the amount of water inside the clothing. Based on studies using the current and modified constant wear immersion suits for CF helicopter crews, survival time would likely exceed 12 hours during cold water immersion in water at 0°C (7, 8) if an immersion suit is used.

## Recommendations

1. The proposed sleeping bag as well as the approved sleeping bag will likely meet the 12-hour survival time criteria during the worst scenario of land survival as long as the bags are kept dry.

2. If the bags can't be kept dry, it is proposed to investigate the use of sleeping bags with synthetic insulation material and with the same packing size to replace the down sleeping bags. This could be an asset for sea survival as well.

3. The proposed and approved balaclavas and mittens provide similar thermal protection and are suitable for a 12-hour survival period.

4. It is advisable for the aircrew to build a bough bed or at least to use the inflatable life raft cushion and LP/SV to insulate the body from the ground during ground survival.

5. The proposed and approved life rafts will unlikely provide sufficient thermal protection for a 12-hour survival period during the worst scenario of sea survival. It is recommended to find a more effective way to insulate the aircrew from heat loss to the water by using a life raft with an inflatable floor or by using an immersion suit during winter flight operations over large bodies of water.

6. The proposed life raft has design limitations that promote heat loss to the water. It is proposed that the sagged floor should be eliminated from the life raft design.

7. The above recommendations were developed from manikin testing and modeling estimations. Further testing with humans, in the laboratory or / and in the field, are recommended to validate the results from the present study and to optimize the equipment in the survival kit.

## References


1. Tikuisis, P. and J. Frim (1994), Prediction of survival time in cold air, DCIEM Report No, 94-29.

2. Tikuisis, P. (1995), Predicting survival time for cold exposure. Int J Biometeorol. 39: pp 94-102.

3. Stewart, L. E. (1985), 1985 Anthropometric survey of Canadian forces aircrew, DCIEM-TR-85-12-01, Defence and Civil Institute of Environmental Medicine, Toronto, Ontario.

4. Chamberland, A., R. Carrier, F. Forest and G. Hachez (1998), Anthropometric survey of the Land Forces (LF97), 98-CR-15, Defence and Civil Institute of Environmental Medicine, Toronto, Ontario.

5. Ducharme, M.B., C.J. Brooks. The effect of wave motion on dry suit insulation and the responses to cold water immersion. Aviat. Space Environ. Med., 69(10); 957-964, 1998.

6. Ducharme, M.B. Thermal resistance of inflatable and non-inflatable floors of a one-man life rafts for the CF199 Escape system. DCIEM Technical Report TR 2001-125, 2001.

7. Ducharme, M.B. A simulated helicopter crash to test a new concept of immersion suit. Proceedings of the 10th International Conference on Environmental Ergonomics, Sept. 23-27, 2002, Fukuoka, Japan, p. 515-518, 2002.

8. Ducharme, M.B., Testing a new concept of immersion suit at sea. NATO Conference Proceedings of the Human Factors & Medicine Panel Symposium on Blowing Hot and Cold Protecting Against Climatic Extremes. Dresden, Germany, 8-10 October: 11.1-11.6, 2002.

# Annexes

## ANNEX A: Results from the Thermal manikin tests

```
TEST NUMBER: 1867
TEST TITLE: COLD WEATHER GARMENT EVALUATION.
FILE NAME: c:\Program Files\tim1_1_34beta\M0311TA6.TM1

DATE OF TEST: 06-12-2003
START TIME: 09:43:14
DESCRIPTION OF SUIT TESTED: WINTER FLIGHT JACKET, COVERALL, PANTS, LINED BOOTS, LEATHER
MITTS WITH WOOL LINERS.
UNDERGARMENTS: WINTER UNDERWEAR: TOP AND BOTTOM,WOOL SOCKS,BALACLAVA.
ENVIRONMENT: 20.5 KM WIND.
  POSITION: LYING ON 6 INCH THICK SPRUCE BOUGH BED WITH FEET TO THE WIND.
  HUMIDITY: 64
  ENV. FLOW SPEED:
  DIRECTION:
CABLE LENGTH: Short (50ft)
ADDITIONAL INFORMATION: PROPOSED SLEEPING BAG # 1 (-4 DEG C),DRY CONDITION.


STOP TIME: 13:55:18              MINUTES SINCE START OF TEST: 252.05
ENVIRONMENT TEMPERATURE:
      INSTANTANEOUS: 22.61            AVERAGE OVER TEST TIME: 21.98
```

| SECTION | SETPOINT (Deg C) | SKINTEMP (Deg C) | TEMP DIFF(Deg C) INSTANT | TEMP DIFF(Deg C) AVERAGE | POWER (WATTS) ST | POWER (WATTS) LT | INSULATION (CLO) ST | INSULATION (CLO) LT |
|---|---|---|---|---|---|---|---|---|
| Head | 35.00 | 35.02 | 12.41 | 13.03 | 6.41 | 7.28 | 1.6949 | 1.5670 |
| Chest | 35.00 | 35.06 | 12.45 | 13.07 | 1.88 | 1.79 | 6.6591 | 7.3298 |
| Back | 35.00 | 35.04 | 12.43 | 13.04 | 2.35 | 3.33 | 5.6626 | 4.1975 |
| Abdomen | 35.00 | 35.03 | 12.42 | 13.04 | 1.46 | 1.56 | 3.0095 | 2.9671 |
| Buttocks | 35.00 | 35.01 | 12.40 | 13.02 | 2.11 | 2.90 | 3.2604 | 2.4982 |
| Right Arm | 35.00 | 35.02 | 12.41 | 13.03 | 3.08 | 3.25 | 2.9498 | 2.9419 |
| Left Arm | 35.00 | 35.02 | 12.41 | 13.04 | 3.42 | 3.11 | 2.3904 | 2.7607 |
| Right Hand | 35.00 | 35.07 | 12.46 | 13.09 | 2.15 | 2.05 | 1.8316 | 2.0244 |
| Left Hand | 35.00 | 35.09 | 12.48 | 13.10 | 1.52 | 1.55 | 2.5523 | 2.6354 |
| Right Leg | 35.00 | 35.04 | 12.43 | 13.05 | 5.77 | 6.51 | 4.9530 | 4.6033 |
| Left Leg | 35.00 | 35.05 | 12.44 | 13.05 | 5.37 | 5.58 | 4.9625 | 5.0134 |
| Right Foot | 35.00 | 35.03 | 12.42 | 13.05 | 2.57 | 2.19 | 2.1355 | 2.6295 |
| Left Foot | 35.00 | 35.02 | 12.41 | 13.05 | 2.53 | 2.08 | 2.1325 | 2.7342 |
| Overall | | | | | 40.63 | 43.16 | 3.4246 | 3.3845 |

```
   Total Power (W) For All Sections: 43.160
   Total Area (Square Meters): 1.736
   Overall Insulation Resistance (CLO): 3.3845
```

TEST NUMBER: 1868
TEST TITLE: COLD WEATHER GARMENT EVALUATION.
FILE NAME: c:\Program Files\tim1_1_34beta\M0311TA7.TM1

DATE OF TEST: 06-12-2003
START TIME: 14:26:32
DESCRIPTION OF SUIT TESTED: WINTER FLIGHT JACKET, COVERALL, PANTS, LINED BOOTS, LEATHER MITTS WITH WOOL LINERS,
UNDERGARMENTS: WINTER UNDERWEAR; TOP AND BOTTOM,WOOL SOCKS,BALACLAVA.
ENVIRONMENT: 20.5 KM WIND
  POSITION: LYING ON 6 INCH THICK SPRUCE BOUGH BED WITH FEET TO THE WIND.
  HUMIDITY: 63
  ENV. FLOW SPEED:
  DIRECTION:
CABLE LENGTH: Short (50ft)
ADDITIONAL INFORMATION: (-30 DEG C) SLEEPING BAG,DRY CONDITION.

STOP TIME: 20:34:29 MINUTES SINCE START OF TEST: 367.95
ENVIRONMENT TEMPERATURE:
INSTANTANEOUS: 24.03 AVERAGE OVER TEST TIME: 23.99

| SECTION | SETPOINT (Deg C) | SKINTEMP (Deg C) | TEMP DIFF(Deg C) INSTANT | TEMP DIFF(Deg C) AVERAGE | POWER (WATTS) ST | POWER (WATTS) LT | INSULATION (CLO) ST | INSULATION (CLO) LT |
|---|---|---|---|---|---|---|---|---|
| Head | 35.00 | 35.03 | 11.00 | 11.03 | 5.65 | 5.90 | 1.7036 | 1.6372 |
| Chest | 35.00 | 35.05 | 11.03 | 11.07 | 1.68 | 1.66 | 6.5928 | 6.7185 |
| Back | 35.00 | 35.02 | 10.99 | 11.04 | 2.36 | 2.69 | 5.0006 | 4.4035 |
| Abdomen | 35.00 | 35.04 | 11.01 | 11.04 | 1.19 | 1.14 | 3.2635 | 3.4333 |
| Buttocks | 35.00 | 35.01 | 10.98 | 11.02 | 3.00 | 2.19 | 2.0359 | 2.7969 |
| Right Arm | 35.00 | 35.06 | 11.03 | 11.05 | 0.94 | 1.70 | 8.5931 | 4.7731 |
| Left Arm | 35.00 | 35.04 | 11.01 | 11.05 | 2.33 | 1.88 | 3.1127 | 3.8787 |
| Right Hand | 35.00 | 35.06 | 11.04 | 11.08 | 1.08 | 0.96 | 3.2316 | 3.6633 |
| Left Hand | 35.00 | 35.08 | 11.06 | 11.09 | 0.77 | 1.23 | 4.4621 | 2.8120 |
| Right Leg | 35.00 | 35.04 | 11.01 | 11.05 | 1.66 | 2.96 | 15.2256 | 8.5771 |
| Left Leg | 35.00 | 35.05 | 11.02 | 11.06 | 3.01 | 3.35 | 7.8293 | 7.0761 |
| Right Foot | 35.00 | 35.09 | 11.06 | 11.06 | 0.50 | 1.34 | 9.6946 | 3.6586 |
| Left Foot | 35.00 | 35.05 | 11.02 | 11.06 | 0.88 | 1.32 | 5.4763 | 3.6466 |
| Overall | | | | | 25.06 | 28.29 | 4.9199 | 4.3732 |

Total Power (W) For All Sections: 28.294
Total Area (Square Meters): 1.736
Overall Insulation Resistance (CLO): 4.3732

TEST NUMBER: 1869
TEST TITLE: COLD WEATHER GARMENT EVALUATION.
FILE NAME: c:\Program Files\timl_1_34beta\M0311TA8.TM1

DATE OF TEST: 06-13-2003
START TIME: 08:25:59
DESCRIPTION OF SUIT TESTED: WINTER FLIGHT JACKET, COVERALL, PANTS, LINER PARKA, LEATHER MITTS WITH WOOL LINERS.
UNDERGARMENTS: WINTER UNDERWEAR; TOP AND BOTTOM,WOOL SOCKS,BALACLAVA.
ENVIRONMENT: 20.5 KM WIND.
  POSITION: LYING ON 6 INCH THICK SPRUCE BOUGH BED WITH FEET TO THE WIND.
  HUMIDITY: 64.5
  ENV. FLOW SPEED:
  DIRECTION:
CABLE LENGTH: Short (50ft)
ADDITIONAL INFORMATION: PROPOSED SLEEPING BAG # 2 (-10 DEG C), DRY CONDITION.

STOP TIME: 12:25:54 MINUTES SINCE START OF TEST: 239.90
ENVIRONMENT TEMPERATURE:
INSTANTANEOUS: 24.61 AVERAGE OVER TEST TIME: 23.33

| SECTION | SETPOINT (Deg C) | SKINTEMP (Deg C) | TEMP DIFF(Deg C) INSTANT | TEMP DIFF(Deg C) AVERAGE | POWER (WATTS) ST | POWER (WATTS) LT | INSULATION (CLO) ST | INSULATION (CLO) LT |
|---|---|---|---|---|---|---|---|---|
| Head | 35.00 | 35.01 | 10.41 | 11.68 | 4.99 | 5.37 | 1.8242 | 1.9061 |
| Chest | 35.00 | 35.05 | 10.45 | 11.73 | 1.29 | 1.56 | 8.1620 | 7.5392 |
| Back | 35.00 | 35.04 | 10.43 | 11.70 | 2.65 | 3.37 | 4.2142 | 3.7255 |
| Abdomen | 35.00 | 35.05 | 10.44 | 11.72 | 0.77 | 1.10 | 4.7361 | 3.7770 |
| Buttocks | 35.00 | 35.01 | 10.40 | 11.68 | 2.65 | 2.66 | 2.1793 | 2.4410 |
| Right Arm | 35.00 | 35.03 | 10.42 | 11.69 | 1.49 | 1.85 | 5.1437 | 4.6407 |
| Left Arm | 35.00 | 35.04 | 10.43 | 11.71 | 1.20 | 1.82 | 5.7107 | 4.2314 |
| Right Hand | 35.00 | 35.07 | 10.46 | 11.74 | 1.09 | 1.12 | 3.0428 | 3.3243 |
| Left Hand | 35.00 | 35.08 | 10.47 | 11.75 | 1.22 | 1.37 | 2.6655 | 2.6661 |
| Right Leg | 35.00 | 35.04 | 10.43 | 11.70 | 5.90 | 5.55 | 4.0607 | 4.8427 |
| Left Leg | 35.00 | 35.04 | 10.43 | 11.70 | 3.61 | 4.61 | 6.1901 | 5.4293 |
| Right Foot | 35.00 | 35.05 | 10.44 | 11.72 | 1.50 | 1.42 | 3.0841 | 3.6543 |
| Left Foot | 35.00 | 35.06 | 10.45 | 11.72 | 0.96 | 1.32 | 4.7543 | 3.8575 |
| Overall | | | | | 29.32 | 33.12 | 3.9828 | 3.9569 |

Total Power (W) For All Sections: 33.118
Total Area (Square Meters): 1.736
Overall Insulation Resistance (CLO): 3.9569

TEST NUMBER: 1870
TEST TITLE: COLD WEATHER GARMENT EVALUATION.
FILE NAME: c:\Program Files\tim1_1_34beta\M0311TA9.TM1

DATE OF TEST: 06-13-2003
START TIME: 15:36:52
DESCRIPTION OF SUIT TESTED: WINTER FLIGHT JACKET, COVERALL, PANTS, LINED BOOTS, LEATHER MITTS WITH WOOL LINERS.
UNDERGARMENTS: WINTER UNDERWEAR; TOP AND BOTTOM, WOOL SOCKS, BALACLAVA.
ENVIRONMENT: 20.5 KM WIND.
  POSITION: SITTING ON 6 INCH THICK SPRUCE BOUGH BED WITH BACK TO THE WIND.
  HUMIDITY: 55
  ENV. FLOW SPEED:
  DIRECTION:
CABLE LENGTH: Short (50ft)
ADDITIONAL INFORMATION: SITTING ON INFLATABLE PILLOW IN CURRENT LIFERAFT, DRY CONDITION.

STOP TIME: 21:48:43 MINUTES SINCE START OF TEST: 371.85
ENVIRONMENT TEMPERATURE:
INSTANTANEOUS: 24.54 AVERAGE OVER TEST TIME: 25.07

| SECTION | SETPOINT (Deg C) | SKINTEMP (Deg C) | TEMP DIFF(Deg C) INSTANT | TEMP DIFF(Deg C) AVERAGE | POWER (WATTS) ST | POWER (WATTS) LT | INSULATION (CLO) ST | INSULATION (CLO) LT |
|---|---|---|---|---|---|---|---|---|
| Head | 35.00 | 35.01 | 10.47 | 9.94 | 5.36 | 5.56 | 1.7095 | 1.5654 |
| Chest | 35.00 | 35.05 | 10.51 | 10.00 | 2.36 | 2.04 | 4.4744 | 4.9305 |
| Back | 35.00 | 35.04 | 10.50 | 9.95 | 1.57 | 3.17 | 7.1926 | 3.3729 |
| Abdomen | 35.00 | 35.03 | 10.48 | 9.96 | 1.45 | 1.23 | 2.5546 | 2.8684 |
| Buttocks | 35.00 | 35.01 | 10.47 | 9.94 | 2.74 | 2.64 | 2.1228 | 2.0904 |
| Right Arm | 35.00 | 35.03 | 10.49 | 9.95 | 1.30 | 2.07 | 5.9274 | 3.5254 |
| Left Arm | 35.00 | 35.02 | 10.48 | 9.95 | 2.07 | 2.41 | 3.3271 | 2.7200 |
| Right Hand | 35.00 | 35.06 | 10.52 | 10.00 | 1.53 | 1.69 | 2.1823 | 1.8789 |
| Left Hand | 35.00 | 35.09 | 10.55 | 10.02 | 1.67 | 1.70 | 1.9612 | 1.8372 |
| Right Leg | 35.00 | 35.02 | 10.48 | 9.95 | 6.09 | 7.62 | 3.9516 | 3.0011 |
| Left Leg | 35.00 | 35.03 | 10.48 | 9.95 | 3.25 | 6.88 | 6.9098 | 3.0946 |
| Right Foot | 35.00 | 35.06 | 10.51 | 9.97 | 1.28 | 1.94 | 3.6324 | 2.2676 |
| Left Foot | 35.00 | 35.03 | 10.49 | 9.97 | 2.25 | 2.11 | 2.0220 | 2.0563 |
| Overall | | | | | 32.92 | 41.05 | 3.5667 | 2.7165 |

Total Power (W) For All Sections: 41.048
Total Area (Square Meters): 1.736
Overall Insulation Resistance (CLO): 2.7165

TEST NUMBER: 1871
TEST TITLE: COLD WEATHER GARMENT EVALUATION.
FILE NAME: c:\Program Files\tim1_1_36beta\M0311TA.0.TM1

DATE OF TEST: 06-16-2003
START TIME: 10:45:51
DESCRIPTION OF SUIT TESTED: WINTER FLIGHT JACKET, COVERALL, PANTS, LINED BOOTS, LEATHER MITTS WITH WOOL LINERS.
UNDERGARMENTS: WINTER UNDERWEAR; TOP AND BOTTOM, WOOL SOCKS, BALACLAVA.
ENVIRONMENT: 20.5 KM WIND.
  POSITION: SITTING ON 6 INCH THICK SPRUCE BOUGH BED WITH BACK TO THE WIND.
  HUMIDITY: 79
  ENV. FLOW SPEED:
  DIRECTION:
CABLE LENGTH: Short (50ft)
ADDITIONAL INFORMATION: SITTING ON INFLATABLE PILLOW IN PROPOSED LIFERAFT, DRY CONDITION.

STOP TIME: 14:45:49 MINUTES SINCE START OF TEST: 239.95
ENVIRONMENT TEMPERATURE:
INSTANTANEOUS: 21.93 AVERAGE OVER TEST TIME: 19.86

| SECTION | SETPOINT (Deg C) | SKINTEMP (Deg C) | TEMP DIFF(Deg C) INSTANT | TEMP DIFF(Deg C) AVERAGE | POWER (WATTS) ST | POWER (WATTS) LT | INSULATION (CLO) ST | INSULATION (CLO) LT |
|---|---|---|---|---|---|---|---|---|
| Head | 35.00 | 35.01 | 13.08 | 15.15 | 7.60 | 9.75 | 1.5070 | 1.3602 |
| Chest | 35.00 | 35.07 | 13.14 | 15.21 | 2.04 | 3.04 | 6.4716 | 5.0233 |
| Back | 35.00 | 35.02 | 13.09 | 15.17 | 3.30 | 3.59 | 4.2547 | 4.5325 |
| Abdomen | 35.00 | 35.01 | 13.08 | 15.16 | 2.20 | 2.32 | 2.1064 | 2.3186 |
| Buttocks | 35.00 | 35.01 | 13.08 | 15.15 | 3.40 | 3.92 | 2.1341 | 2.1470 |
| Right Arm | 35.00 | 35.02 | 13.09 | 15.16 | 3.59 | 4.51 | 2.6709 | 2.4646 |
| Left Arm | 35.00 | 35.01 | 13.08 | 15.15 | 3.50 | 4.00 | 2.4588 | 2.4959 |
| Right Hand | 35.00 | 35.09 | 13.16 | 15.23 | 2.11 | 2.36 | 1.9712 | 2.0432 |
| Left Hand | 35.00 | 35.08 | 13.15 | 15.24 | 1.87 | 2.14 | 2.1890 | 2.2175 |
| Right Leg | 35.00 | 35.02 | 13.09 | 15.17 | 11.73 | 11.10 | 2.5653 | 3.1403 |
| Left Leg | 35.00 | 35.02 | 13.09 | 15.16 | 9.16 | 10.63 | 3.0605 | 3.0532 |
| Right Foot | 35.00 | 35.03 | 13.10 | 15.17 | 2.42 | 3.21 | 2.3947 | 2.0907 |
| Left Foot | 35.00 | 35.04 | 13.11 | 15.19 | 2.68 | 3.13 | 2.1265 | 2.1104 |
| Overall | | | | | 55.61 | 63.69 | 2.6371 | 2.6669 |

Total Power (W) For All Sections: 63.685
Total Area (Square Meters): 1.736
Overall Insulation Resistance (CLO): 2.6669

TEST NUMBER: 1872
TEST TITLE: COLD WEATHER GARMENT EVALUATION.
FILE NAME: c:\Program Files\tim1_1_34beta\M0311TA11.TM1

DATE OF TEST: 06-16-2003
START TIME: 15:05:04
DESCRIPTION OF SUIT TESTED: WINTER FLIGHT JACKET, COVERALL, PANTS, LINED BOOTS, LEATHER MITTS WITH WOOL LINERS.
UNDERGARMENTS: WINTER UNDERWEAR; TOP AND BOTTOM, WOOL SOCKS, BALACLAVA.
ENVIRONMENT: 20.5 KM WIND.
  POSITION: SITTING ON 6 INCH THICK SPRUCE BOUGH BED WITH BACK TO THE WIND.
  HUMIDITY: 64
  ENV. FLOW SPEED:
  DIRECTION:
CABLE LENGTH: Short (50ft)
ADDITIONAL INFORMATION: SITTING ON INFLATABLE PILLOW IN (-30 DEG C) SLEEPING BAG, IN CURRENT LIFERAFT, DRY CONDITION.

STOP TIME: 23:04:57 MINUTES SINCE START OF TEST: 479.90
ENVIRONMENT TEMPERATURE:
INSTANTANEOUS: 22.40 AVERAGE OVER TEST TIME: 22.70

| SECTION | SETPOINT (Deg C) | SKINTEMP (Deg C) | TEMP DIFF (Deg C) INSTANT | TEMP DIFF (Deg C) AVERAGE | POWER (WATTS) ST | POWER (WATTS) LT | INSULATION (CLO) ST | INSULATION (CLO) LT |
|---|---|---|---|---|---|---|---|---|
| Head | 35.00 | 35.01 | 12.61 | 12.32 | 6.74 | 5.46 | 1.6395 | 1.9754 |
| Chest | 35.00 | 35.06 | 12.66 | 12.37 | 1.60 | 1.28 | 7.9289 | 9.7265 |
| Back | 35.00 | 35.06 | 12.66 | 12.35 | 0.88 | 1.29 | 15.3619 | 10.2574 |
| Abdomen | 35.00 | 35.05 | 12.65 | 12.35 | 1.13 | 1.10 | 3.9618 | 3.9671 |
| Buttocks | 35.00 | 35.01 | 12.62 | 12.32 | 3.30 | 2.53 | 2.1247 | 2.7080 |
| Right Arm | 35.00 | 35.05 | 12.66 | 12.33 | 0.76 | 1.73 | 12.2187 | 5.2322 |
| Left Arm | 35.00 | 35.02 | 12.62 | 12.34 | 2.11 | 2.01 | 3.9280 | 4.0346 |
| Right Hand | 35.00 | 35.07 | 12.67 | 12.37 | 1.10 | 1.11 | 3.6614 | 3.5189 |
| Left Hand | 35.00 | 35.09 | 12.70 | 12.39 | 0.88 | 1.15 | 4.4747 | 3.3589 |
| Right Leg | 35.00 | 35.05 | 12.65 | 12.37 | 4.94 | 2.81 | 5.8834 | 10.1263 |
| Left Leg | 35.00 | 35.01 | 12.62 | 12.33 | 4.92 | 4.16 | 5.4915 | 6.3510 |
| Right Foot | 35.00 | 35.05 | 12.65 | 12.35 | 1.27 | 1.40 | 4.3934 | 3.8950 |
| Left Foot | 35.00 | 35.06 | 12.66 | 12.36 | 1.17 | 1.34 | 4.7263 | 4.0183 |
| Overall | | | | | 30.81 | 27.36 | 4.5929 | 5.0508 |

Total Power (W) For All Sections: 27.361
Total Area (Square Meters): 1.736
Overall Insulation Resistance (CLO): 5.0508

TEST NUMBER: 1#73
TEST TITLE: COLD WEATHER GARMENT EVALUATION.
FILE NAME: c:\Program Files\tim1_1_34beta\M0311TA12.TM1

DATE OF TEST: 06-17-2003
START TIME: 10:03:14
DESCRIPTION OF SUIT TESTED: WINTER FLIGHT JACKET, COVERALL, PANTS, SINGLE BOOTS, PROPOSED MITTS.
UNDERGARMENTS: WINTER UNDERWEAR; TOP AND BOTTOM, WOOL SOCKS, PROPOSED BALACLAVA.
ENVIRONMENT: 20.5 KM WIND
  POSITION: SITTING ON 6 INCH THICK SPRUCE BOUGH BED WITH BACK TO THE WIND.
  HUMIDITY: 55
  ENV. FLOW SPEED:
  DIRECTION:
CABLE LENGTH: Short (50ft)
ADDITIONAL INFORMATION: SITTING ON INFLATABLE PILLOW IN (-4 DEG C) PROPOSED SLEEPING BAG # 1 IN PROPOSED LIFERAFT, DRY CONDITION.

STOP TIME: 15:31:59 MINUTES SINCE START OF TEST: 328.75
ENVIRONMENT TEMPERATURE:
INSTANTANEOUS: 25.05 AVERAGE OVER TEST TIME: 23.24

| SECTION | SETPOINT (Deg C) | SKINTEMP (Deg C) | TEMP DIFF (Deg C) INSTANT | TEMP DIFF (Deg C) AVERAGE | POWER (WATTS) ST | POWER (WATTS) LT | INSULATION (CLO) ST | INSULATION (CLO) LT |
|---|---|---|---|---|---|---|---|---|
| Head | 35.00 | 35.00 | 9.96 | 11.76 | 6.98 | 8.38 | 1.2491 | 1.2293 |
| Chest | 35.00 | 35.06 | 10.01 | 11.82 | 1.35 | 1.69 | 7.4455 | 7.0412 |
| Back | 35.00 | 35.07 | 10.02 | 11.80 | 0.70 | 1.76 | 15.3457 | 7.2017 |
| Abdomen | 35.00 | 35.07 | 10.02 | 11.81 | 0.26 | 0.96 | 13.7555 | 4.3340 |
| Buttocks | 35.00 | 35.02 | 9.98 | 11.77 | 1.48 | 2.28 | 3.7561 | 2.8621 |
| Right Arm | 35.00 | 35.01 | 9.96 | 11.77 | 2.33 | 3.36 | 3.1319 | 2.5638 |
| Left Arm | 35.00 | 35.03 | 9.99 | 11.77 | 2.31 | 3.39 | 2.8468 | 2.2861 |
| Right Hand | 35.00 | 35.08 | 10.04 | 11.83 | 1.33 | 1.43 | 2.3954 | 2.6158 |
| Left Hand | 35.00 | 35.09 | 10.04 | 11.84 | 1.10 | 1.21 | 2.8424 | 3.0401 |
| Right Leg | 35.00 | 35.04 | 10.00 | 11.77 | 4.25 | 6.50 | 5.4006 | 4.1613 |
| Left Leg | 35.00 | 35.02 | 9.97 | 11.78 | 6.48 | 4.60 | 3.2964 | 5.4798 |
| Right Foot | 35.00 | 35.02 | 9.97 | 11.79 | 1.83 | 1.88 | 2.4119 | 2.7707 |
| Left Foot | 35.00 | 35.04 | 9.99 | 11.80 | 1.83 | 1.48 | 2.3792 | 3.4704 |
| Overall | | | | | 32.21 | 38.93 | 3.4697 | 3.3885 |

Total Power (W) For All Sections: 38.933
Total Area (Square Meters): 1.736
Overall Insulation Resistance (CLO): 3.3885

TEST NUMBER: 1874
TEST TITLE: COLD WEATHER GARMENT EVALUATION.
FILE NAME: c:\Program Files\tim1_1_36beta\M0311TA13.TM1

DATE OF TEST: 06-17-2003
START TIME: 16:03:37
DESCRIPTION OF SUIT TESTED: WINTER FLIGHT JACKET, COVERALL, PANTS, LINER BOOTS, INSULATED MITTS.
UNDERGARMENTS: WINTER UNDERWEAR; TOP AND BOTTOM, WOOL SOCKS, PROPOSED BALACLAVA.
ENVIRONMENT: 20.5 KM WIND.
  POSITION: SITTING ON 6 INCH THICK SPRUCE BOUGH BED WITH BACK TO THE WIND..
  HUMIDITY: 54
  ENV. FLOW SPEED:
  DIRECTION:
CABLE LENGTH: Short (50ft)
ADDITIONAL INFORMATION: SITTING ON INFLATABLE PILLOW IN (-10 DEG C) PROPOSED SLEEPING BAG # 2 IN PROPOSED LIFE RAFT, DRY CONDITION.

STOP TIME: 22:03:34 MINUTES SINCE START OF TEST: 359.95
ENVIRONMENT TEMPERATURE:
INSTANTANEOUS: 24.41 AVERAGE OVER TEST TIME: 24.66

| SECTION | SETPOINT (Deg C) | SKINTEMP (Deg C) | TEMP DIFF(Deg C) INSTANT | TEMP DIFF(Deg C) AVERAGE | POWER (WATTS) ST | POWER (WATTS) LT | INSULATION (CLO) ST | INSULATION (CLO) LT |
|---|---|---|---|---|---|---|---|---|
| Head | 35.00 | 35.00 | 10.59 | 10.35 | 5.93 | 5.01 | 1.5645 | 1.8075 |
| Chest | 35.00 | 35.07 | 10.66 | 10.41 | 1.26 | 1.09 | 8.4684 | 9.5803 |
| Back | 35.00 | 35.06 | 10.66 | 10.39 | 1.24 | 1.21 | 9.2151 | 9.1757 |
| Abdomen | 35.00 | 35.05 | 10.64 | 10.39 | 0.82 | 0.75 | 4.6002 | 4.9257 |
| Buttocks | 35.00 | 35.02 | 10.61 | 10.35 | 1.57 | 1.83 | 3.7622 | 3.1401 |
| Right Arm | 35.00 | 35.00 | 10.60 | 10.35 | 3.64 | 2.50 | 2.1350 | 3.0335 |
| Left Arm | 35.00 | 35.01 | 10.61 | 10.36 | 3.63 | 2.57 | 1.9205 | 2.6557 |
| Right Hand | 35.00 | 35.08 | 10.67 | 10.40 | 1.10 | 1.19 | 3.0798 | 2.7737 |
| Left Hand | 35.00 | 35.07 | 10.66 | 10.41 | 1.20 | 1.00 | 2.7676 | 3.2296 |
| Right Leg | 35.00 | 35.01 | 10.61 | 10.37 | 4.25 | 4.77 | 5.7324 | 4.9957 |
| Left Leg | 35.00 | 35.03 | 10.63 | 10.38 | 2.97 | 3.70 | 7.6684 | 6.0070 |
| Right Foot | 35.00 | 35.06 | 10.65 | 10.38 | 0.83 | 1.24 | 5.6549 | 3.6848 |
| Left Foot | 35.00 | 35.04 | 10.63 | 10.38 | 1.31 | 1.20 | 3.5253 | 3.7735 |
| Overall | | | | | 29.75 | 28.07 | 3.9962 | 4.1373 |

Total Power (W) For All Sections: 28.067
Total Area (Square Meters): 1.736
Overall Insulation Resistance (CLO): 4.1373

TEST NUMBER: 1875
TEST TITLE: COLD WEATHER GARMENT EVALUATION.
FILE NAME: c:\Program Files\tim_1_tests\N0311TA14.TMI

DATE OF TEST: 06-18-2003
START TIME: 10:56:59
DESCRIPTION OF SUIT TESTED: [illegible] SLEEPING BAG (-30 DEG C).
UNDERGARMENTS: NIL.
ENVIRONMENT: 20.5 KM WIND.
  POSITION: LYING ON 6 INCH THICK SPRUCE BOUGH BED WITH FEET TO THE WIND.
  HUMIDITY: 50
  ENV. FLOW SPEED:
  DIRECTION:
CABLE LENGTH: Short (50ft)
ADDITIONAL INFORMATION: SIMULATED WET CONDITION.

STOP TIME: 15:56:56 MINUTES SINCE START OF TEST: 299.95
ENVIRONMENT TEMPERATURE:
INSTANTANEOUS: 25.51 AVERAGE OVER TEST TIME: 24.01

| SECTION | SETPOINT (Deg C) | SKINTEMP (Deg C) | TEMP DIFF (Deg C) INSTANT | TEMP DIFF (Deg C) AVERAGE | POWER (WATTS) ST | POWER (WATTS) LT | INSULATION (CLO) ST | INSULATION (CLO) LT |
|---|---|---|---|---|---|---|---|---|
| Head | 35.00 | 35.01 | 9.50 | 11.00 | 5.98 | 7.05 | 1.3910 | 1.3654 |
| Chest | 35.00 | 35.04 | 9.53 | 11.06 | 2.78 | 1.97 | 3.4440 | 5.6382 |
| Back | 35.00 | 35.04 | 9.53 | 11.02 | 2.60 | 3.30 | 3.9391 | 3.5799 |
| Abdomen | 35.00 | 35.01 | 9.50 | 11.02 | 1.84 | 1.62 | 1.8277 | 2.4089 |
| Buttocks | 35.00 | 35.01 | 9.50 | 11.01 | 3.22 | 3.15 | 1.6391 | 1.9424 |
| Right Arm | 35.00 | 35.02 | 9.50 | 11.02 | 1.52 | 1.64 | 4.5708 | 4.9204 |
| Left Arm | 35.00 | 35.01 | 9.50 | 11.01 | 4.00 | 3.56 | 1.5635 | 2.0375 |
| Right Hand | 35.00 | 35.06 | 9.55 | 11.06 | 1.04 | 0.96 | 2.9021 | 3.6395 |
| Left Hand | 35.00 | 35.09 | 9.57 | 11.08 | 1.12 | 1.33 | 2.6696 | 2.5837 |
| Right Leg | 35.00 | 35.06 | 9.55 | 11.05 | 1.72 | 2.91 | 12.7874 | 8.7215 |
| Left Leg | 35.00 | 35.03 | 9.52 | 11.02 | 3.49 | 4.93 | 5.8400 | 4.7821 |
| Right Foot | 35.00 | 35.02 | 9.51 | 11.03 | 1.64 | 1.60 | 2.5677 | 3.0374 |
| Left Foot | 35.00 | 35.03 | 9.52 | 11.03 | 1.61 | 1.84 | 2.5719 | 2.6036 |
| Overall | | | | | 32.55 | 35.88 | 3.2737 | 3.4400 |

Total Power (W) For All Sections: 35.879
Total Area (Square Meters): 1.736
Overall Insulation Resistance (CLO): 3.4400

TEST NUMBER: 1876
TEST TITLE: COLD WEATHER GARMENT EVALUATION.
FILE NAME: c:\Program Files\tinl [illegible]

DATE OF TEST: 06-18-2003
START TIME: 17:16:04
DESCRIPTION OF SUIT TESTED: [illegible]
UNDERGARMENTS: NIL.
ENVIRONMENT: 20.5 KM WIND.
  POSITION: LYING ON 6 INCH THICK SPRUCE BOUGH BED WITH FEET TO THE WIND.
  HUMIDITY: 55
  ENV. FLOW SPEED:
  DIRECTION:
CABLE LENGTH: Short (50ft)
ADDITIONAL INFORMATION: SIMULATED WET CONDITION.

STOP TIME: 23:16:01 MINUTES SINCE START OF TEST: 359.95
ENVIRONMENT TEMPERATURE:
INSTANTANEOUS: 24.72 AVERAGE OVER TEST TIME: 25.07

| SECTION | SETPOINT (Deg C) | SKINTEMP (Deg C) | TEMP DIFF (Deg C) INSTANT | TEMP DIFF (Deg C) AVERAGE | POWER (WATTS) ST | POWER (WATTS) LT | INSULATION (CLO) ST | INSULATION (CLO) LT |
|---|---|---|---|---|---|---|---|---|
| Head | 35.00 | 35.01 | 10.29 | 9.94 | 4.93 | 4.51 | 1.8297 | 1.9284 |
| Chest | 35.00 | 35.06 | 10.34 | 10.00 | 3.30 | 1.99 | 3.1463 | 5.0441 |
| Back | 35.00 | 35.04 | 10.32 | 9.96 | 2.54 | 3.09 | 4.3521 | 3.4524 |
| Abdomen | 35.00 | 35.04 | 10.32 | 9.97 | 1.69 | 1.25 | 2.1691 | 2.8317 |
| Buttocks | 35.00 | 35.03 | 10.31 | 9.96 | 1.95 | 1.67 | 2.9386 | 3.3089 |
| Right Arm | 35.00 | 35.03 | 10.31 | 9.95 | 1.62 | 2.03 | 4.6607 | 3.5907 |
| Left Arm | 35.00 | 35.02 | 10.30 | 9.96 | 2.66 | 1.97 | 2.5461 | 3.3215 |
| Right Hand | 35.00 | 35.06 | 10.34 | 10.00 | 1.32 | 1.44 | 2.4780 | 2.2045 |
| Left Hand | 35.00 | 35.10 | 10.38 | 10.01 | 1.07 | 1.34 | 3.0158 | 2.3265 |
| Right Leg | 35.00 | 35.02 | 10.30 | 9.94 | 6.84 | 6.67 | 3.4591 | 3.4258 |
| Left Leg | 35.00 | 35.02 | 10.30 | 9.95 | 4.20 | 4.08 | 5.2491 | 5.2255 |
| Right Foot | 35.00 | 35.02 | 10.31 | 9.96 | 2.09 | 1.56 | 2.1774 | 2.8275 |
| Left Foot | 35.00 | 35.03 | 10.32 | 9.97 | 1.59 | 1.47 | 2.8223 | 2.9388 |
| Overall | | | | | 35.80 | 33.08 | 3.2245 | 3.3714 |

Total Power (W) For All Sections: 33.078
Total Area (Square Meters): 1.736
Overall Insulation Resistance (CLO): 3.3714

TEST NUMBER: 1877
TEST TITLE: COLD WEATHER GARMENT EVALUATION.
FILE NAME: C:\Program Files\tinl_1_34beta\MS\LITAIN.INI

DATE OF TEST: 04-19-2001
START TIME: 07:49:15
DESCRIPTION OF SUIT TESTED: TWOCOLD SLEEPING BAG & 1 T-T SHIRT
ENVIRONMENT: NIL.
ENV. FLOW SPEED: 20.5 KM WIND.
  POSITION: LYING ON 6 INCH THICK SPRUCE WOOD BED WITH FEET IN AIR.
  HUMIDITY: 50
  ENV. FLOW SPEED:
  DIRECTION:
CABLE LENGTH: Short (50ft)
ADDITIONAL INFORMATION: SIMULATED WET CONDITION.

STOP TIME: 10:49:13 MINUTES SINCE START OF TEST: 179.96
ENVIRONMENT TEMPERATURE:
INSTANTANEOUS: 20.09 AVERAGE OVER TEST TIME: 19.49

| SECTION | SETPOINT (Deg C) | SKINTEMP (Deg C) | TEMP DIFF(Deg C) INSTANT | TEMP DIFF(Deg C) AVERAGE | POWER (WATTS) ST | POWER (WATTS) LT | INSULATION (CLO) ST | INSULATION (CLO) LT |
|---|---|---|---|---|---|---|---|---|
| Head | 35.00 | 35.00 | 14.91 | 15.73 | 25.99 | 27.76 | 0.5021 | 0.4963 |
| Chest | 35.00 | 35.07 | 14.97 | 15.81 | 5.89 | 5.59 | 2.5521 | 2.8438 |
| Back | 35.00 | 35.01 | 14.92 | 15.75 | 7.66 | 7.48 | 2.0300 | 2.2589 |
| Abdomen | 35.00 | 35.00 | 14.91 | 15.74 | 3.90 | 3.98 | 1.3558 | 1.4027 |
| Buttocks | 35.00 | 35.01 | 14.92 | 15.75 | 3.91 | 3.44 | 2.1204 | 2.5401 |
| Right Arm | 35.00 | 35.00 | 14.91 | 15.74 | 7.15 | 7.86 | 1.5290 | 1.4666 |
| Left Arm | 35.00 | 35.01 | 14.91 | 15.74 | 5.30 | 5.68 | 1.8536 | 1.8223 |
| Right Hand | 35.00 | 35.12 | 15.02 | 15.86 | 5.04 | 5.13 | 0.9447 | 0.9800 |
| Left Hand | 35.00 | 35.15 | 15.06 | 15.89 | 4.84 | 4.57 | 0.9673 | 1.0808 |
| Right Leg | 35.00 | 35.01 | 14.92 | 15.75 | 13.64 | 13.46 | 2.5136 | 2.6894 |
| Left Leg | 35.00 | 35.01 | 14.92 | 15.75 | 9.73 | 11.44 | 3.2827 | 2.9468 |
| Right Foot | 35.00 | 35.04 | 14.94 | 15.76 | 3.12 | 3.59 | 2.1137 | 1.9431 |
| Left Foot | 35.00 | 35.03 | 14.94 | 15.77 | 2.79 | 2.80 | 2.3253 | 2.4479 |
| Overall | | | | | 98.95 | 102.78 | 1.6897 | 1.7170 |

Total Power (W) For All Sections: 102.776
Total Area (Square Meters): 1.736
Overall Insulation Resistance (CLO): 1.7170

TEST NUMBER: 1474
TEST TITLE: [illegible] WEATHER GARMENT EVALUATION
FILE NAME: [illegible] Files\Data_1 Tests\2003\1474.TMO

DATE OF TEST: [illegible]
START TIME: [illegible]
[illegible] TEST SUBJECT: [illegible] LIFE SAVE

[illegible] FOR WORK:
[illegible] [illegible] ON A COLD TALOS CHAMBER WORKS SET WITH HEAT TO [illegible]

ENV. FLOW SPEED:
DIRECTION:
CABLE LENGTH: [illegible] (feet)
ADDITIONAL INFORMATION: SITTING ON INFLATABLE PILLOW IN CURRENT LIFE VEST; [illegible] WET
CONDITION:

TEST TIME: [illegible] MINUTES SINCE START OF TEST: 119.95
ENVIRONMENT TEMPERATURE:
INSTANTANEOUS: 21.09 AVERAGE OVER TEST TIME: 20.65

| SECTION | SETPOINT SKINTEMP (Deg C) | | TEMP DIFF(Deg C) | | POWER (WATTS) | | INSULATION (CLO) | |
|---|---|---|---|---|---|---|---|---|
| | (Deg C) | (Deg C) | INSTANT | AVERAGE | ST | LT | ST | LT |
| Head | 35.00 | 35.00 | 13.91 | 14.35 | 27.66 | 26.45 | 0.6852 | 0.6417 |
| Chest | 35.00 | 35.08 | 13.99 | 14.44 | 13.61 | 13.48 | 1.0327 | 1.0760 |
| Back | 35.00 | 35.00 | 13.91 | 14.35 | 30.76 | 32.12 | 0.4851 | 0.4969 |
| Abdomen | 35.00 | 35.00 | 13.91 | 14.36 | 6.93 | 7.08 | 0.7112 | 0.7178 |
| Buttocks | 35.00 | 35.00 | 13.91 | 14.36 | 7.15 | 7.03 | 1.0807 | 1.1365 |
| Right Arm | 35.00 | 35.00 | 13.91 | 14.35 | 15.83 | 15.17 | 0.6442 | 0.6935 |
| Left Arm | 35.00 | 35.00 | 13.91 | 14.35 | 14.28 | 14.53 | 0.6411 | 0.6498 |
| Right Hand | 35.00 | 35.09 | 14.00 | 14.45 | 4.26 | 3.92 | 1.0414 | 1.1674 |
| Left Hand | 35.00 | 35.15 | 14.06 | 14.51 | 5.35 | 5.19 | 0.8176 | 0.8692 |
| Right Leg | 35.00 | 35.01 | 13.92 | 14.35 | 39.61 | 43.32 | 0.8077 | 0.7616 |
| Left Leg | 35.00 | 35.00 | 13.91 | 14.35 | 42.79 | 43.67 | 0.6961 | 0.7038 |
| Right Foot | 35.00 | 35.03 | 13.94 | 14.38 | 10.14 | 10.97 | 0.6072 | 0.5792 |
| Left Foot | 35.00 | 35.05 | 13.96 | 14.39 | 9.66 | 10.76 | 0.6286 | 0.5850 |
| Overall | | | | | 228.02 | 234.44 | 0.6838 | 0.6856 |

Total Power (W) For All Sections: 234.444
Total Area (Square Meters): 1.736
Overall Insulation Resistance (CLO): 0.6856

TEST NUMBER: 1887
TEST TITLE: COLD WEATHER GARMENT EVALUATION.
FILE NAME: c:\Program Files\tiny_t_jr\data\M03\1TA18.TM1

DATE OF TEST: 06-24-2003
START TIME: 09:57:15
DESCRIPTION OF SUBJ TESTED: [illegible] LIFERAFT.
UNDERGARMENTS: NIL.
ENVIRONMENT: 20.5 KM WIND.
  POSITION: SITTING ON 4 INCH THICK FOAM SQUOH BED WITH BACK TO THE WIND.
  HUMIDITY: 59
  ENV. FLOW SPEED:
  DIRECTION: From Back
CABLE LENGTH: Short (50ft)
ADDITIONAL INFORMATION: SITTING ON INFLATABLE PILLOW IN PROPOSED LIFE RAFT, SIMULATED WET CONDITION.

STOP TIME: 11:57:13 MINUTES SINCE START OF TEST: 119.95
ENVIRONMENT TEMPERATURE:
INSTANTANEOUS: 24.36 AVERAGE OVER TEST TIME: 24.09

| SECTION | SETPOINT (Deg C) | SKINTEMP (Deg C) | TEMP DIFF(Deg C) INSTANT | TEMP DIFF(Deg C) AVERAGE | POWER (WATTS) ST | POWER (WATTS) LT | INSULATION (CLO) ST | INSULATION (CLO) LT |
|---|---|---|---|---|---|---|---|---|
| Head | 35.00 | 35.00 | 10.64 | 10.91 | 18.66 | 19.78 | 0.4991 | 0.4831 |
| Chest | 35.00 | 35.10 | 10.74 | 11.01 | 7.69 | 8.75 | 1.4022 | 1.2637 |
| Back | 35.00 | 35.01 | 10.65 | 10.92 | 11.75 | 11.98 | 0.9721 | 0.9781 |
| Abdomen | 35.00 | 35.01 | 10.66 | 10.93 | 4.49 | 4.65 | 0.8412 | 0.8330 |
| Buttocks | 35.00 | 35.01 | 10.65 | 10.92 | 6.82 | 6.83 | 0.8671 | 0.8876 |
| Right Arm | 35.00 | 35.01 | 10.65 | 10.92 | 5.42 | 6.53 | 1.4393 | 1.2264 |
| Left Arm | 35.00 | 35.00 | 10.65 | 10.92 | 9.80 | 9.78 | 0.7146 | 0.7346 |
| Right Hand | 35.00 | 35.09 | 10.73 | 11.01 | 3.16 | 3.03 | 1.0766 | 1.1524 |
| Left Hand | 35.00 | 35.13 | 10.77 | 11.05 | 4.26 | 3.83 | 0.7870 | 0.8961 |
| Right Leg | 35.00 | 35.00 | 10.64 | 10.92 | 29.78 | 27.35 | 0.8213 | 0.9175 |
| Left Leg | 35.00 | 35.00 | 10.65 | 10.92 | 25.56 | 25.91 | 0.8916 | 0.9024 |
| Right Foot | 35.00 | 35.01 | 10.66 | 10.94 | 6.52 | 6.47 | 0.7228 | 0.7471 |
| Left Foot | 35.00 | 35.06 | 10.70 | 10.97 | 5.32 | 5.76 | 0.8742 | 0.8273 |
| Overall | | | | | 139.24 | 140.65 | 0.8571 | 0.8704 |

Total Power (W) For All Sections: 140.654
Total Area (Square Meters): 1.736
Overall Insulation Resistance (CLO): 0.8704

TEST NUMBER: 1888
TEST TITLE: COLD WEATHER GARMENT EVALUATION.
FILE NAME: c:\Program Files\tjm[illegible]

DATE OF TEST: 06-25-2003
START TIME: 11:13:34
DESCRIPTION OF SUIT TESTED: [illegible]
UNDERGARMENTS: NIL.
ENVIRONMENT: 20.5 KM WIND.
  POSITION: SITTING ON 6 INCH THICK SPRUCE BOUGH BED WITH BACK TO THE WIND.
  HUMIDITY: 55
  ENV. FLOW SPEED:
  DIRECTION:
CABLE LENGTH: Short (50ft)
ADDITIONAL INFORMATION: SITTING ON INFLATABLE PILLOW IN CURRENT LIFE RAFT, SIMULATED WET CONDITION.

STOP TIME: 21:13:29 MINUTES SINCE START OF TEST: 599.90
ENVIRONMENT TEMPERATURE:
INSTANTANEOUS: 22.30 AVERAGE OVER TEST TIME: 21.15

| SECTION | SETPOINT (Deg C) | SKINTEMP (Deg C) | TEMP DIFF (Deg C) INSTANT | TEMP DIFF (Deg C) AVERAGE | POWER (WATTS) ST | POWER (WATTS) LT | INSULATION (CLO) ST | INSULATION (CLO) LT |
|---|---|---|---|---|---|---|---|---|
| Head | 35.00 | 35.00 | 12.70 | 13.86 | 14.40 | 13.96 | 0.7723 | 0.8690 |
| Chest | 35.00 | 35.06 | 12.76 | 13.92 | 1.31 | 1.60 | 9.8073 | 8.7129 |
| Back | 35.00 | 35.06 | 12.76 | 13.90 | 1.02 | 1.18 | 13.4854 | 12.6585 |
| Abdomen | 35.00 | 35.05 | 12.75 | 13.89 | 0.78 | 0.88 | 5.7607 | 5.5888 |
| Buttocks | 35.00 | 35.01 | 12.71 | 13.87 | 2.20 | 2.44 | 3.2120 | 3.1626 |
| Right Arm | 35.00 | 35.05 | 12.75 | 13.88 | 1.10 | 1.92 | 8.4754 | 5.3094 |
| Left Arm | 35.00 | 35.03 | 12.73 | 13.87 | 2.65 | 3.20 | 3.1617 | 2.8539 |
| Right Hand | 35.00 | 35.07 | 12.77 | 13.93 | 1.09 | 1.16 | 3.7089 | 3.7887 |
| Left Hand | 35.00 | 35.10 | 12.80 | 13.94 | 1.00 | 1.22 | 3.9959 | 3.5623 |
| Right Leg | 35.00 | 35.02 | 12.72 | 13.87 | 5.73 | 7.18 | 5.1035 | 4.4391 |
| Left Leg | 35.00 | 35.04 | 12.74 | 13.88 | 4.22 | 4.92 | 6.4692 | 6.0388 |
| Right Foot | 35.00 | 35.05 | 12.75 | 13.89 | 0.91 | 1.27 | 6.2212 | 4.8511 |
| Left Foot | 35.00 | 35.05 | 12.75 | 13.91 | 1.04 | 1.06 | 5.3416 | 5.6916 |
| Overall | | | | | 37.43 | 41.99 | 3.8066 | 3.7007 |

Total Power (W) For All Sections: 41.988
Total Area (Square Meters): 1.736
Overall Insulation Resistance (CLO): 3.7007

TEST NUMBER: 1889
TEST TITLE: COLD WEATHER GARMENT EVALUATION.
FILE NAME: c:\Program Files\timl_1_34beta\M0311TA20.TN1

DATE OF TEST: 06-26-2003
START TIME: 15:47:11
DESCRIPTION OF SUIT TESTED: PROPOSED SLEEPING BAG # 2 (1.736 SQ. M).
UNDERGARMENTS: NIL.
ENVIRONMENT: 20.5 KM WIND.
  POSITION: SITTING ON 6 INCH THICK SPRUCE BOUGH BED WITH BACK TO THE WIND
  HUMIDITY: 59
  ENV. FLOW SPEED:
  DIRECTION:
CABLE LENGTH: Short (50ft)
ADDITIONAL INFORMATION: SITTING ON INFLATABLE PILLOW IN PROPOSED LIFE RAFT, SIMULATED WET CONDITION.

STOP TIME: 22:47:07 MINUTES SINCE START OF TEST: 419.95
ENVIRONMENT TEMPERATURE:
INSTANTANEOUS: 24.75 AVERAGE OVER TEST TIME: 25.59

| SECTION | SETPOINT (Deg C) | SKINTEMP (Deg C) | TEMP DIFF (Deg C) INSTANT | TEMP DIFF (Deg C) AVERAGE | POWER (WATTS) ST | POWER (WATTS) LT | INSULATION (CLO) ST | INSULATION (CLO) LT |
|---|---|---|---|---|---|---|---|---|
| Head | 35.00 | 35.01 | 10.27 | 9.42 | 5.32 | 4.65 | 1.6886 | 1.7732 |
| Chest | 35.00 | 35.06 | 10.31 | 9.47 | 1.56 | 1.53 | 6.6199 | 6.2109 |
| Back | 35.00 | 35.04 | 10.29 | 9.45 | 2.09 | 1.62 | 5.2809 | 6.2515 |
| Abdomen | 35.00 | 35.04 | 10.29 | 9.45 | 0.49 | 0.54 | 7.3794 | 6.1842 |
| Buttocks | 35.00 | 35.02 | 10.28 | 9.43 | 1.43 | 1.63 | 3.9985 | 3.2114 |
| Right Arm | 35.00 | 35.02 | 10.28 | 9.42 | 2.72 | 3.06 | 2.7679 | 2.2528 |
| Left Arm | 35.00 | 35.03 | 10.29 | 9.43 | 2.00 | 2.87 | 3.3923 | 2.1667 |
| Right Hand | 35.00 | 35.06 | 10.31 | 9.48 | 1.07 | 0.74 | 3.0626 | 4.0576 |
| Left Hand | 35.00 | 35.08 | 10.34 | 9.50 | 0.99 | 1.50 | 3.2503 | 1.9751 |
| Right Leg | 35.00 | 35.03 | 10.28 | 9.43 | 5.23 | 5.75 | 4.5217 | 3.7707 |
| Left Leg | 35.00 | 35.03 | 10.29 | 9.43 | 3.04 | 4.69 | 7.2430 | 4.3096 |
| Right Foot | 35.00 | 35.03 | 10.29 | 9.44 | 1.70 | 1.41 | 2.6755 | 2.9594 |
| Left Foot | 35.00 | 35.04 | 10.30 | 9.46 | 0.96 | 0.91 | 4.6548 | 4.5416 |
| Overall | | | | | 28.60 | 30.89 | 4.0269 | 3.4209 |

Total Power (W) For All Sections: 30.891
Total Area (Square Meters): 1.736
Overall Insulation Resistance (CLO): 3.4209

TEST NUMBER: 1890
TEST TITLE: COLD WEATHER GARMENT EVALUATION.
FILE NAME: c:\Program Files\tim1_1_34beta\M0311TA21.TM1

DATE OF TEST: 06-27-2003
START TIME: 9:46:37
DESCRIPTION OF SUIT TESTED: PROPOSED SLEEPING BAG # 1 (-4 DEG C).
UNDERGARMENTS: NIL.
ENVIRONMENT: 20.5 KM WIND.
POSITION: SITTING ON 6 INCH THICK SPRUCE BOUGH BED WITH BACK TO THE WIND.
HUMIDITY: 50
ENV. FLOW SPEED:
DIRECTION:
CABLE LENGTH: Short (50ft)
ADDITIONAL INFORMATION: SITTING ON INFLATABLE PILLOW IN PROPOSED LIFERAFT, SIMULATED WET CONDITION.

STOP TIME: 16:13:33 MINUTES SINCE START OF TEST: 326.95
ENVIRONMENT TEMPERATURE:
INSTANTANEOUS: 24.10 AVERAGE OVER TEST TIME: 24.51

| SECTION | SETPOINT (Deg C) | SKINTEMP (Deg C) | TEMP DIFF(Deg C) INSTANT | TEMP DIFF(Deg C) AVERAGE | POWER (WATTS) ST | POWER (WATTS) LT | INSULATION (CLO) ST | INSULATION (CLO) LT |
|---|---|---|---|---|---|---|---|---|
| Head | 35.00 | 35.02 | 10.93 | 10.51 | 8.56 | 9.77 | 1.1181 | 0.9418 |
| Chest | 35.00 | 35.04 | 10.94 | 10.55 | 3.38 | 2.01 | 3.2568 | 5.2793 |
| Back | 35.00 | 35.04 | 10.94 | 10.53 | 1.44 | 1.74 | 8.1460 | 6.5016 |
| Abdomen | 35.00 | 35.03 | 10.93 | 10.53 | 1.73 | 0.95 | 2.2344 | 3.9412 |
| Buttocks | 35.00 | 35.02 | 10.92 | 10.50 | 1.48 | 2.35 | 4.0910 | 2.4847 |
| Right Arm | 35.00 | 35.01 | 10.92 | 10.52 | 5.71 | 3.45 | 1.4017 | 2.2360 |
| Left Arm | 35.00 | 35.01 | 10.91 | 10.52 | 4.12 | 3.26 | 1.7427 | 2.1213 |
| Right Hand | 35.00 | 35.08 | 10.99 | 10.57 | 1.94 | 1.81 | 1.7967 | 1.8461 |
| Left Hand | 35.00 | 35.06 | 10.96 | 10.58 | 1.55 | 1.40 | 2.1961 | 2.3583 |
| Right Leg | 35.00 | 35.05 | 10.95 | 10.51 | 2.75 | 9.79 | 9.1393 | 2.4697 |
| Left Leg | 35.00 | 35.03 | 10.93 | 10.53 | 3.61 | 4.60 | 6.4803 | 4.8985 |
| Right Foot | 35.00 | 35.01 | 10.92 | 10.52 | 2.79 | 1.95 | 1.7313 | 2.3888 |
| Left Foot | 35.00 | 35.03 | 10.93 | 10.54 | 1.63 | 1.25 | 2.9205 | 3.6566 |
| Overall | | | | | 40.69 | 44.32 | 3.0087 | 2.6589 |

Total Power (W) For All Sections: 44.319
Total Area (Square Meters): 1.736
Overall Insulation Resistance (CLO): 2.6589

TEST NUMBER: 1891
TEST TITLE: COLD WEATHER GARMENT EVALUATION.
FILE NAME: c:\Program Files\timl 1_36beta\m0311ta22.TM1

DATE OF TEST: 06-30-[illegible]
START TIME: 09:58:37
DESCRIPTION OF SUIT [illegible]: CURRENT ISSUING BAG ( -30 DEG C).
UNDERGARMENTS: NIL.
ENVIRONMENT: [illegible] KM W/V.
  POSITION: LYING ON 6 INCH THICK SPRUCE BOUGH BED WITH FEET TO THE WIND.
  HUMIDITY: 64
  ENV. FLOW SPEED:
  DIRECTION:
CABLE LENGTH: Short (50ft)
ADDITIONAL INFORMATION: INFLATED LIFE JACKET PLACED UNDER TORSO IN BOUGH BED, SIMULATED WET CONDITION.

STOP TIME: 16:43:39 MINUTES SINCE START OF TEST: 405.55
ENVIRONMENT TEMPERATURE:
INSTANTANEOUS: 22.58 AVERAGE OVER TEST TIME: 24.19

| SECTION | SETPOINT (Deg C) | SKINTEMP (Deg C) | TEMP DIFF(Deg C) INSTANT | TEMP DIFF(Deg C) AVERAGE | POWER (WATTS) ST | POWER (WATTS) LT | INSULATION (CLO) ST | INSULATION (CLO) LT |
|---|---|---|---|---|---|---|---|---|
| Head | 35.00 | 35.00 | 12.42 | 10.82 | 10.99 | 10.95 | 0.9895 | 0.8651 |
| Chest | 35.00 | 35.06 | 12.48 | 10.88 | 2.35 | 2.00 | 5.3383 | 5.4639 |
| Back | 35.00 | 35.04 | 12.46 | 10.84 | 2.00 | 2.75 | 6.6783 | 4.2328 |
| Abdomen | 35.00 | 35.04 | 12.46 | 10.85 | 1.04 | 0.96 | 4.2331 | 4.0178 |
| Buttocks | 35.00 | 35.01 | 12.43 | 10.83 | 2.56 | 2.45 | 2.6920 | 2.4513 |
| Right Arm | 35.00 | 35.01 | 12.43 | 10.84 | 1.50 | 1.42 | 6.0700 | 5.6015 |
| Left Arm | 35.00 | 35.03 | 12.45 | 10.83 | 2.04 | 2.84 | 4.0190 | 2.5087 |
| Right Hand | 35.00 | 35.07 | 12.49 | 10.88 | 0.66 | 0.89 | 5.9804 | 3.8600 |
| Left Hand | 35.00 | 35.07 | 12.49 | 10.89 | 1.47 | 0.90 | 2.6407 | 3.7575 |
| Right Leg | 35.00 | 35.03 | 12.45 | 10.84 | 5.05 | 6.02 | 5.6637 | 4.1408 |
| Left Leg | 35.00 | 35.02 | 12.44 | 10.85 | 5.53 | 3.86 | 4.8198 | 6.0212 |
| Right Foot | 35.00 | 35.02 | 12.44 | 10.85 | 2.68 | 1.57 | 2.0486 | 3.0466 |
| Left Foot | 35.00 | 35.05 | 12.47 | 10.86 | 1.34 | 1.26 | 4.0456 | 3.7435 |
| Overall | | | | | 39.22 | 37.87 | 3.5525 | 3.2049 |

Total Power (W) For All Sections: 37.869
Total Area (Square Meters): 1.736
Overall Insulation Resistance (CLO): 3.2049

TEST NUMBER: 1892
TEST TITLE: COLD WEATHER GARMENT EVALUATION.
FILE NAME: c:\Program Files\timl [illegible]

DATE OF TEST: 07-02-2003
START TIME: 12:15:51
DESCRIPTION OF SUIT TESTED: [illegible], COVERALL, PANTS, LINED BOOTS, LEATHER
MITTS WITH WOOL LINERS.
UNDERGARMENTS: WINTER UNDERWEAR; [illegible], WOOL SOCKS, BALACLAVA.
ENVIRONMENT: 20.5 KM WIND.
  POSITION: SITTING IN LIFERAFT IN WATER.
  HUMIDITY: 60
  ENV. FLOW SPEED:
  DIRECTION:
CABLE LENGTH: Short (50ft)
ADDITIONAL INFORMATION: SITTING ON INFLATABLE IN CURRENT LIFERAFT, WET CONDITION, 8
LITRES OF WATER ADDED TO THE LIFERAFT.

STOP TIME: 16:15:49 MINUTES SINCE START OF TEST: 239.95
ENVIRONMENT TEMPERATURE:
INSTANTANEOUS: 25.48 AVERAGE OVER TEST TIME: 24.69

| SECTION | SETPOINT (Deg C) | SKINTEMP (Deg C) | TEMP DIFF(Deg C) INSTANT | TEMP DIFF(Deg C) AVERAGE | POWER (WATTS) ST | POWER (WATTS) LT | INSULATION (CLO) ST | INSULATION (CLO) LT |
|---|---|---|---|---|---|---|---|---|
| Head | 31.50 | 31.53 | 6.05 | 6.83 | 2.60 | 4.22 | 2.0372 | 1.4157 |
| Chest | 31.50 | 31.56 | 6.07 | 6.87 | 4.33 | 4.27 | 1.4093 | 1.6152 |
| Back | 31.50 | 31.51 | 6.02 | 6.82 | 8.42 | 8.33 | 0.7679 | 0.8791 |
| Abdomen | 31.50 | 31.52 | 6.03 | 6.83 | 4.22 | 3.95 | 0.5063 | 0.6117 |
| Buttocks | 31.50 | 31.46 | 5.98 | 6.79 | 43.26 | 40.90 | 0.0768 | 0.0922 |
| Right Arm | 31.50 | 31.51 | 6.02 | 6.82 | 5.41 | 5.45 | 0.8163 | 0.9166 |
| Left Arm | 31.50 | 31.50 | 6.02 | 6.82 | 5.97 | 5.93 | 0.6638 | 0.7567 |
| Right Hand | 31.50 | 31.60 | 6.11 | 6.91 | 3.16 | 3.41 | 0.6117 | 0.6423 |
| Left Hand | 31.50 | 31.62 | 6.14 | 6.93 | 3.18 | 3.45 | 0.6010 | 0.6256 |
| Right Leg | 31.50 | 31.50 | 6.01 | 6.81 | 152.05 | 142.81 | 0.0909 | 0.1096 |
| Left Leg | 31.50 | 31.50 | 6.02 | 6.81 | 108.05 | 108.28 | 0.1193 | 0.1347 |
| Right Foot | 31.50 | 31.52 | 6.03 | 6.83 | 5.73 | 5.95 | 0.4654 | 0.5077 |
| Left Foot | 31.50 | 31.54 | 6.06 | 6.86 | 5.70 | 6.06 | 0.4619 | 0.4918 |
| Overall | | | | | 352.07 | 343.01 | 0.1914 | 0.2225 |

Total Power (W) For All Sections: 343.013
Total Area (Square Meters): 1.736
Overall Insulation Resistance (CLO): 0.2225

Note: Total water removed from life raft was 32 litres.

TEST NUMBER: 1893
TEST TITLE: COLD WEATHER GARMENT EVALUATION.
FILE NAME: c:\tim1\M0311TA24.TM1

DATE OF TEST: 07-03-2003
START TIME: 12:07:29
DESCRIPTION OF SUIT TESTED: WINTER FLIGHT JACKET, COVERALL, PANTS, LINED BOOTS, PROPOSED MITTS.
UNDERGARMENTS: WINTER UNDERWEAR: TOP AND BOTTOM, [illegible] BALACLAVA.
ENVIRONMENT: 20.5 KM WIND.
  POSITION: SITTING IN LIFERAFT IN WATER.
  HUMIDITY: 64
  ENV. FLOW SPEED:
  DIRECTION:
CABLE LENGTH: Short (50ft)
ADDITIONAL INFORMATION: SITTING ON INFLATABLE PILLOW IN PROPOSED LIFERAFT,WET CONDITION, 8 LITRES OF WATER ADDED TO THE LIFERAFT.

STOP TIME: 14:37:27 MINUTES SINCE START OF TEST: 149.95
ENVIRONMENT TEMPERATURE:
INSTANTANEOUS: 24.75 AVERAGE OVER TEST TIME: 24.73

| SECTION | SETPOINT (Deg C) | SKINTEMP (Deg C) | TEMP DIFF (Deg C) INSTANT | TEMP DIFF (Deg C) AVERAGE | POWER (WATTS) ST | POWER (WATTS) LT | INSULATION (CLO) ST | INSULATION (CLO) LT |
|---|---|---|---|---|---|---|---|---|
| Head | 29.80 | 29.81 | 5.06 | 5.07 | 4.33 | 4.14 | 1.0219 | 1.0727 |
| Chest | 29.80 | 29.87 | 5.12 | 5.12 | 2.82 | 2.98 | 1.8252 | 1.7262 |
| Back | 29.80 | 29.80 | 5.04 | 5.06 | 21.50 | 21.31 | 0.2516 | 0.2545 |
| Abdomen | 29.80 | 29.80 | 5.05 | 5.07 | 5.01 | 4.49 | 0.3572 | 0.3992 |
| Buttocks | 29.80 | 29.79 | 5.04 | 5.05 | 37.10 | 36.94 | 0.0754 | 0.0759 |
| Right Arm | 29.80 | 29.79 | 5.04 | 5.04 | 8.79 | 7.22 | 0.4201 | 0.5116 |
| Left Arm | 29.80 | 29.81 | 5.06 | 5.06 | 6.11 | 6.78 | 0.5446 | 0.4912 |
| Right Hand | 29.80 | 29.83 | 5.08 | 5.09 | 14.19 | 13.38 | 0.1133 | 0.1204 |
| Left Hand | 29.80 | 29.89 | 5.14 | 5.13 | 12.31 | 12.29 | 0.1298 | 0.1298 |
| Right Leg | 29.80 | 29.65 | 4.89 | 4.72 | 165.33 | 163.70 | 0.0680 | 0.0663 |
| Left Leg | 29.80 | 29.80 | 5.05 | 5.05 | 86.42 | 87.12 | 0.1252 | 0.1242 |
| Right Foot | 29.80 | 29.83 | 5.08 | 5.09 | 1.00 | 1.45 | 2.2440 | 1.5560 |
| Left Foot | 29.80 | 29.83 | 5.08 | 5.09 | 2.01 | 2.31 | 1.0988 | 0.9597 |
| Overall | | | | | 366.93 | 364.10 | 0.1520 | 0.1507 |

Total Power (W) For All Sections: 364.099
Total Area (Square Meters): 1.736
Overall Insulation Resistance (CLO): 0.1507

**DOCUMENT CONTROL DATA SHEET**

1a. PERFORMING AGENCY
DRDC Toronto , Cord Group, B2Y 4K9

2. SECURITY CLASSIFICATION
UNCLASSIFIED

1b. PUBLISHING AGENCY
DRDC Toronto

3. TITLE
(U) Thermal resistance and estimated survival for the equipment in the CT 156 Harvard II aircraft seat survival kit

4. AUTHORS
M.B. Ducharme, P. Tikuisis, P. Potter

5. DATE OF PUBLICATION
July 1 , 2003

6. NO. OF PAGES
47

7. DESCRIPTIVE NOTES

8. SPONSORING/MONITORING/CONTRACTING/TASKING AGENCY
Sponsoring Agency:
Monitoring Agency:
Contracting Agency : Canadian Aerospace Training Project (CATP)
Tasking Agency:

9. ORIGINATORS DOCUMENT NO.
Technical Report TR 2003-109

10. CONTRACT GRANT AND/OR PROJECT NO.
FE A3471AAM52

11. OTHER DOCUMENT NOS.

12. DOCUMENT RELEASABILITY
Unlimited distribution

13. DOCUMENT ANNOUNCEMENT
Unlimited announcement

14. ABSTRACT

(U) The main objective of the present study was to compare the thermal resistance properties of new proposed and current equipment of the CT 156 Harvard II survival kit, and to estimate the survival time of aircrew during simulated winter survival scenarios using the proposed and approved survival kits. A thermal manikin was used to measure the thermal resistance of the survival kit equipment. Nineteen survival scenarios were tested representing dry and wet simulations on the ground and at sea. Survival time were estimated for all scenarios tested using the Cold Exposure Survival Model (CESM), the thermal resistance values obtained from the manikin, and CF aircrew anthropometric data. The results showed that only 4 of the 19 scenarios produced an estimated survival time of less than 12 hours, the minimum survival time selected as criteria to pass the test. Those failing scenarios represented wet conditions on land using only the life raft to protect against heat loss, or the wet condition at sea. It was concluded from those results that as long as the sleeping bags are dry, any survival scenario on land using the proposed or approved equipment will produce an estimated survival time of over 12 hours. At sea, however, the estimated survival time is less than 12 hours for both the proposed and approved survival kit equipment when the clothing and equipment are wet. Functional limitations are reported for the proposed life raft.

(U) La présente étude avait pour objectif principal de comparer les propriétés de résistance thermique des équipements, proposés et actuels, contenus dans la trousse de survie à bord du CT 156 Harvard II et d'estimer le temps de survie des membres d'un équipage d'aéronef utilisant les trousses de survie proposées et approuvées au cours de scénarios de simulations de survie en hiver. Un mannequin thermique a été utilisé pour déterminer la résistance thermique de l'équipement contenu dans la trousse de survie. Les essais ont été effectués au cours de dix-neuf scénarios de survie se déroulant sur terre et en mer, dans des conditions humides et des conditions sèches. Le modèle de survie à une exposition au froid (MSEF), les valeurs de résistance thermique obtenues du mannequin et les données anthropométriques de l'équipage des FC ont servi à l'estimation du temps de survie dans tous les scénarios d'essai. Selon les résultats, pour 4 des 19 scénarios, le temps de survie estimé était inférieur à 12 heures, soit le temps de survie établi comme critère de réussite. Les scénarios qui ont donné des résultats insatisfaisants correspondent aux conditions humides sur terre où les participants ne disposaient que du radeau de sauvetage pour se protéger contre la perte de chaleur, et aux conditions humides en mer. Les résultats ont permis de conclure que tant que les sacs de couchage sont secs, le temps de survie estimé de tout scénario sur terre, avec l'équipement proposé ou approuvé, sera de plus de 12 heures. Toutefois, en mer, qu'il s'agisse de l'équipement de la trousse de survie proposé ou approuvé, si l'équipement et les vêtements sont mouillés, le temps de survie estimé est inférieur à 12 heures. On a également signalé des limitations fonctionnelles du radeau de sauvetage proposé.

15. KEYWORDS, DESCRIPTORS or IDENTIFIERS

(U) thermal manikin; survival time; cold exposure; cold water exposure; seat pack